TM 11-2653

WAR DEPARTMENT TECHNICAL MANUAL

VACUUM TUBE VOLTMETER

PRECISION MODEL EV-10-MCP

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WAR DEPARTMENT • JULY 1945

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This manual supersedes TM 11-2653, 23 December 1944.

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TM 11-2653, Vacuum Tube Voltmeter (Precision model EV-10-MCP), is published for the information and guidance of all concerned.

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DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW—1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut—Use axes, handaxes, machetes.

3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

4. Explosives—Use firearms, grenades, TNT.

5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—1. Smash—Tubes, meter, transformer, rotary switches, and cabinet.

2. Cut—Cables and cords.

3. Burn—Cables, cords, circuit diagrams, instruction books, etc.

4. Bend—Panel and chassis.

5. Bury or scatter—All equipment.

DESTROY EVERYTHING

SAFETY NOTICE

Voltages as high as 6,000 volts may be used in the operation of this equipment. These voltages are dangerous to life. Follow the procedures given in paragraph 12 when making voltage measurements.

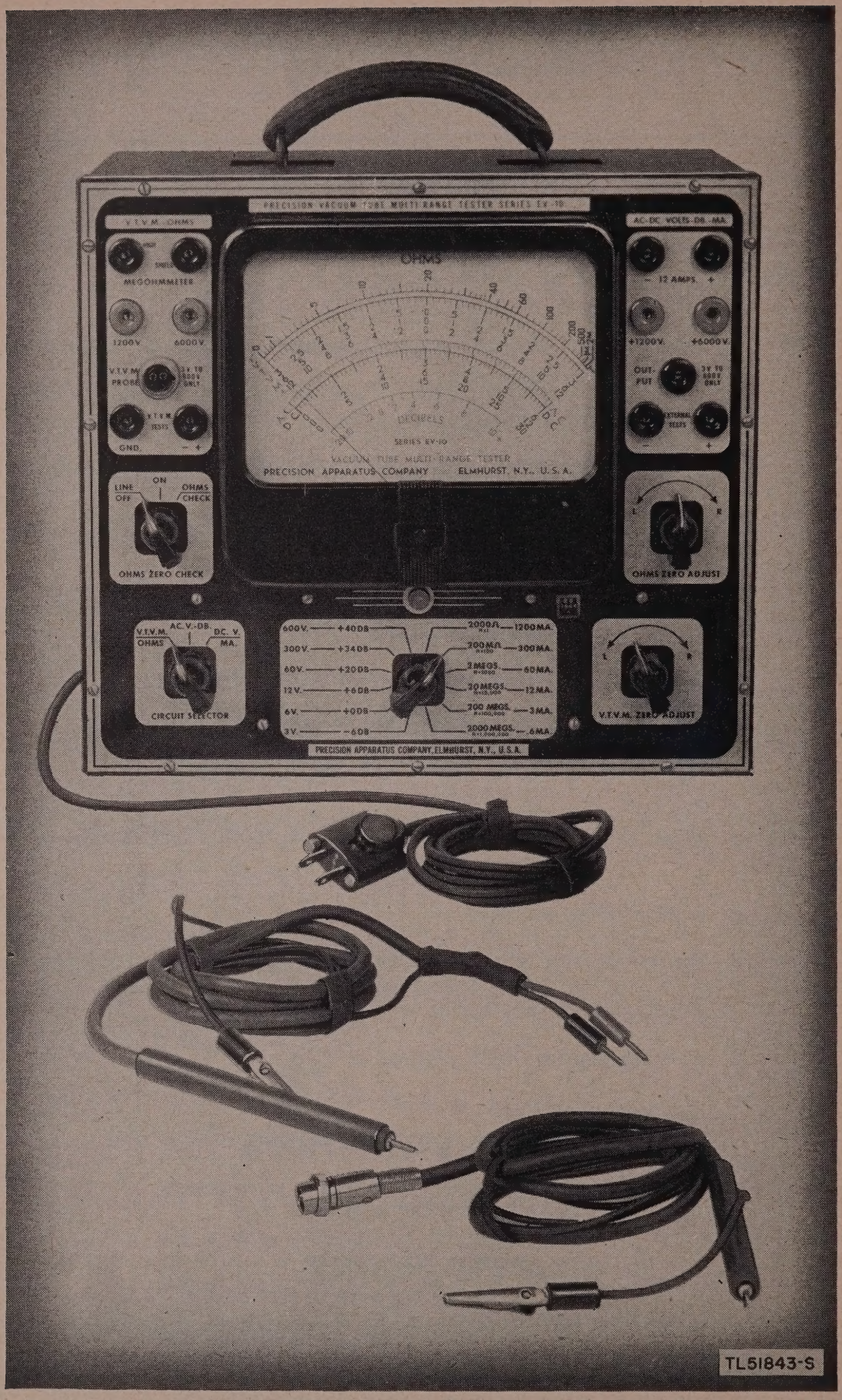

Figure 1. Vacuum tube voltmeter (Precision model EV-10-MCP), general view.

This manual supersedes TM 11-2653, 23 December, 1944

PART ONE

INTRODUCTION

Section I. DESCRIPTION

1. General

Vacuum Tube Voltmeter (Precision Model EV-10-MCP) (fig. 1) is a combination test instrument designed to measure voltage, current, and resistance. All measurements are registered on a single, multiscaled meter. This multirange tester is accurate to 3 percent for direct-current (d-c) and 5 percent for alternating-current (a-c) readings.

a. D-C VOLTAGE MEASUREMENTS (VTVM). D-c voltage, between 0 and 6,000 volts may be measured over eight ranges by means of a vacuum-tube voltmeter (VTVM) circuit. The input impedance is so high that measurements may be made without appreciably loading the circuit under test.

b. RESISTANCE MEASUREMENTS. The VTVM circuit, with slight modifications, is also the basic circuit for the resistance tests. Six ranges cover a series of resistance values between 0 and 2,000 megohms (megs).

c. D-C CURRENT MEASUREMENTS. There are seven ranges over which d-c current values between 0 and 12 amperes are measured. For these tests, the meter and a special set of resistors are used.

d. A-C VOLTAGE MEASUREMENTS. A-c voltage between 0 and 6,000 volts may be measured over eight ranges. A copper-oxide rectifier limits measurements to a-c voltage at frequencies below 8,000 cycles per second.

e. DECIBEL MEASUREMENTS. The a-c voltage measurements circuit is also used for decibel measurements between —26 and +70 decibels (db). The meter has a specially calibrated scale on which db readings are taken.

f. OUTPUT TESTS. The a-c voltmeter may also be used as an output meter. An OUTPUT pin jack terminal on the front panel of the instrument is used for output tests.

g. D-C VOLTMETER (1,000 OHMS PER VOLT). Measurements between 0 and 6,000 volts may be made over eight d-c voltage ranges without connecting the equipment to an a-c power source. In this case, the VTVM circuit is not used. The meter, together with suitable resistors, is connected in a conventional d-c voltmeter circuit. The input resistance for this type of operation is 1,000 ohms per volt.

2. Technical Characteristics

Voltage ranges:

D-c (VTVM)	0 to 3 volts, 0 to 6 volts, 0 to 12 volts, 0 to 60 volts, 0 to 300 volts, 0 to 600 volts, 0 to 1,200 volts, 0 to 6,000 volts.
D-c (1,000 ohms per volt)	0 to 3 volts, 0 to 6 volts, 0 to 12 volts, 0 to 60 volts, 0 to 300 volts, 0 to 600 volts, 0 to 1,200 volts, 0 to 6,000 volts.
A-c	0 to 3 r-m-s volts, 0 to 6 r-m-s volts, 0 to 12 r-m-s volts, 0 to 60 r-m-s volts, 0 to 300 r-m-s volts, 0 to 600 r-m-s volts, 0 to 1,200 r-m-s volts, 0 to 6,000 r-m-s volts.
Resistance ranges	0 to 2,000 ohms 0 to 200,000 ohms 0 to 2 megs, 0 to 20 megs, 0 to 200 megs, 0 to 2,000 megs.
D-c current ranges	0 to 0.6 ma, 0 to 3 ma, 0 to 12 ma, 0 to 60 ma, 0 to 300 ma, 0 to 1,200 ma, 0 to 12 amp.

Decibel ranges.....—26 to +4 db,
—20 to +10 db,
—14 to +16 db,
0 to +30 db,
+14 to +44 db,
+20 to +50 db,
+26 to +56 db,
+40 to +70 db.

Output tests: Same as a-c voltages above.

Frequency range for a-c voltage measurements... Up to approximately 8,000 cycles per second.

Accuracy:

D-c voltage measurements.....3%.

A-c voltage measurements.....5%

Number of tubes.....3.

Power source.....110 to 120 volts; 50 to 60 cycles alternating current.

Figure 2. Front panel view.

3. Description of Major Components

This multirange tester is contained in a portable metal cabinet 12¼ inches high, 11¾ inches wide and 7 inches deep (fig. 1). It weighs 17 pounds. On top of the cabinet is a leather carrying handle. The a-c line cord extends from the back of the cabinet. The 7-inch rectangular meter dominates the front panel (fig. 2). Flanking it on both sides are 13 red and black, button type pin jacks to which the test leads are connected, and the V.T.V.M. PROBE socket for the circuit isolating test leads cable. Centered beneath the meter is a white pilot light which goes on when power is applied to the VTVM circuits. Below the pilot light is the master-range selector switch, a 12-position control for selecting the various voltage, resistance, current, and decibel readings. Two control knobs, in the lower right-hand corner, the OHMS ZERO ADJUST, and the V.T.V.M. ZERO ADJUST are used to adjust the pointer of the meter for VTVM measurements. There are two knobs in the opposite corner: the OHMS ZERO CHECK and the CIRCUIT SELECTOR. The OHMS ZERO CHECK switch is used to make meter zero adjustments for resistance ranges, and serves as the a-c power switch for the VTVM circuits. The CIRCUIT SELECTOR switch connects the proper circuits for the measurements circuits.

4. List of Components

The following table gives the weights and dimensions of the major components of the multirange tester.

Note. This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

a. Equipment Supplied.

Quantity	Name of component	Dimensions (inches)				Unit weight (lb.)
		Height	Width	Depth	Length	
	Vacuum tube voltmeter (Precision model EV-10-MCP).	12¼	11¾	7	..	17
1	Circuit isolating VTVM cable	....	....	..	35	0.5
1	Standard VTVM and ohm cable	....	....	..	35	0.5
1	Set of standard test leads (1 black, 1 red).	....	....	..	36	0.5
1	Set of spare tubes: JAN-OD-3/VR-150 JAN-6X5 JAN-6C5GT/G	....	....	..	..	0.5
2	TM 11-2653.....	9	5⅞	..	..	0.5

b. Equipment Required but not Supplied.

Quantity	Name of component	Unit Weight (lb.)
4	Batteries BA-30	1

5. Packaging Data

The multirange tester and accessories are packed in a wooden box 23 inches long, 17½ inches wide, and 13½ inches deep. This box occupies 3.14 cu. ft. of space. The shipping weight is 60 pounds. For dimensions of the unpacked equipment, see paragraph 4.

Section II. INSTALLATION AND ASSEMBLY

6. Unpacking and Checking

Note. Unpack and handle this equipment with great care. It may be easily damaged.

a. UNPACKING. When unpacking the equipment use the following steps:

(1) Place the box where it may be opened easily.

(2) Cut and remove the metal bands on the outside of the box.

(3) Remove the top.

(4) Open the top of the outer carton and remove the carton from the box.

(5) Lift the moistureproof vaporproof bag from the outer carton.

(6) Open one side of the bag and pull out the inner carton.

(7) Open the top of the inner carton.

(8) Remove the dunnage and carefully lift the instrument from the inner carton.

b. CHECKING. (1) Inspect the instrument thoroughly to see if it has been damaged during shipment.

(2) Check the components against the master packing slip and the list of components in paragraph 4.

(3) Remove the 12 screws around the front panel and lift the chassis from the cabinet. Then make sure that all vacuum tubes are set securely in their proper sockets.

Note. Do not remove the protective varnish from any part of the equipment. It is there to safeguard the set against moisture and fungus growth. (See Sec. VIII.)

7. Installation and Assembly

a. TUBES. The multirange tester is packed with the operating tubes installed.

b. BATTERIES (fig. 3.) Space is reserved inside the cabinet for four Batteries BA-30, or equal, used in the resistance measurements circuit. Install batteries as follows:

(1) Remove the chassis from the cabinet after taking out the 12 screws along the edge of the front panel.

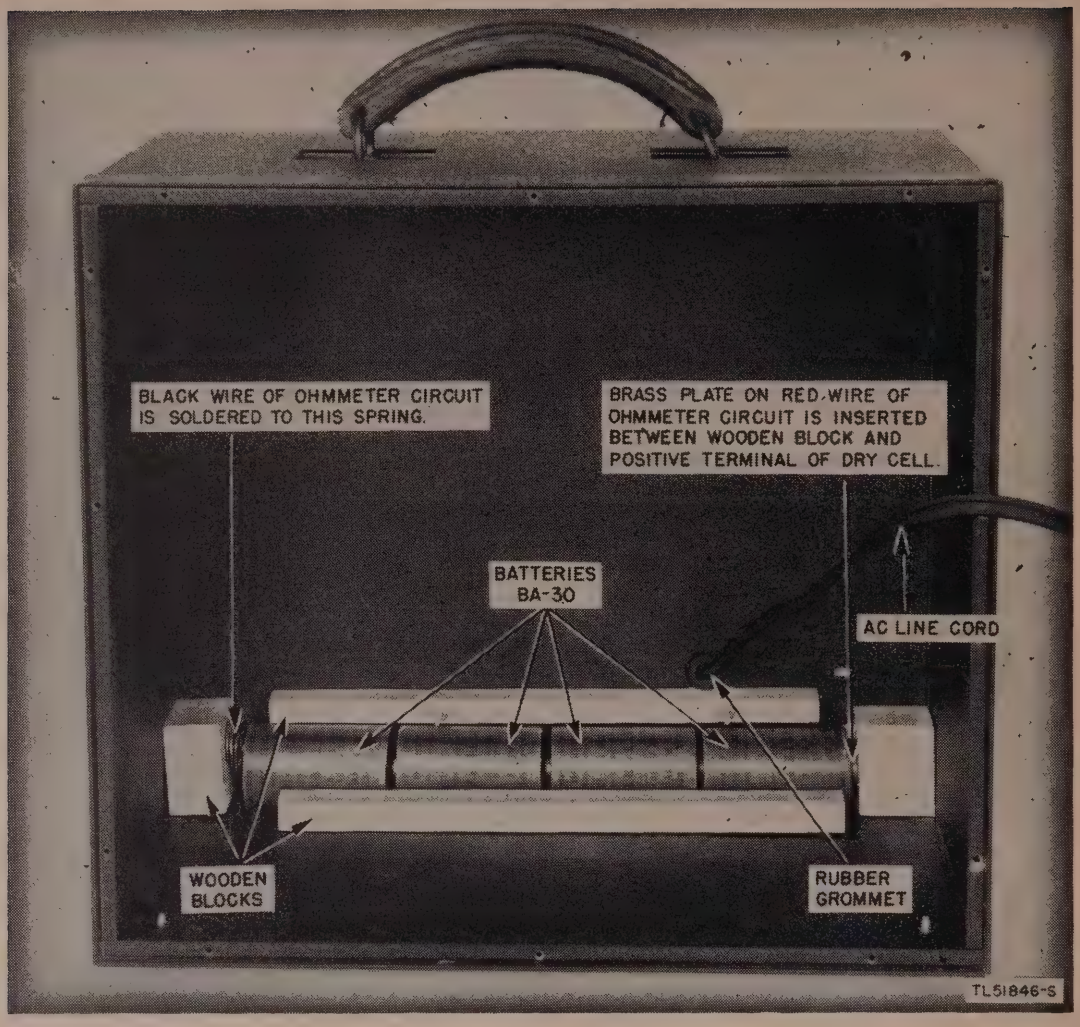

Figure 3. Battery compartment.

(2) Remove the wooden holding strip on the back inside panel of the cabinet after taking off the two nuts which fasten it in place.

(3) Solder the red lead extending from the chassis to the positive terminal (brass terminal) on one of the batteries. (See note below.)

(4) Insert the battery into the groove so that the positive soldered terminal (or the metal plate on the red lead) rests against the right-hand wooden block.

(5) Insert another one of the batteries into the groove so that its negative terminal rests against the spring in the lower left-hand corner of the cabinet.

Note. On some equipments, a metal plate is already soldered to the end of the red lead. In this case, soldering is unnecessary.

(6) Place the other two batteries in the groove in the positions which will electrically connect the batteries in series (positive terminal of one battery against negative terminal of the adjoining battery). It may be necessary, when inserting the last battery in place, to press hard against the spring to make room for all four batteries.

(7) Finally, replace the wooden strip, its two holding nuts, and the chassis in the cabinet.

c. Assembly. (1) Insert the two-prong plug on the circuit isolating test leads cable (fig. 5) into the V.T.V.M. PROBE socket on the front panel.

(2) Insert the cord tips of the standard test leads into the desired pin jacks.

Note. See sections III and IV before using this equipment.

8. Removal from Service

When the equipment is not used, make sure that the OHMS ZERO CHECK switch is in the LINE OFF position and that the line cord is removed from the a-c power source. If the equipment is to be stored for a period *exceeding 2 weeks* or if it is to be shipped to a new location, carefully repack the components into the wooden container from which they were removed. Follow the unpacking procedure in reverse (par. 6).

Note. Remove dry-cell batteries from the cabinet whenever the equipment is stored or removed from service for an extended period of time.

PART TWO

OPERATING INSTRUCTIONS

Note. For information on destroying the equipment to prevent enemy use, see the destruction notice at the front of the manual.

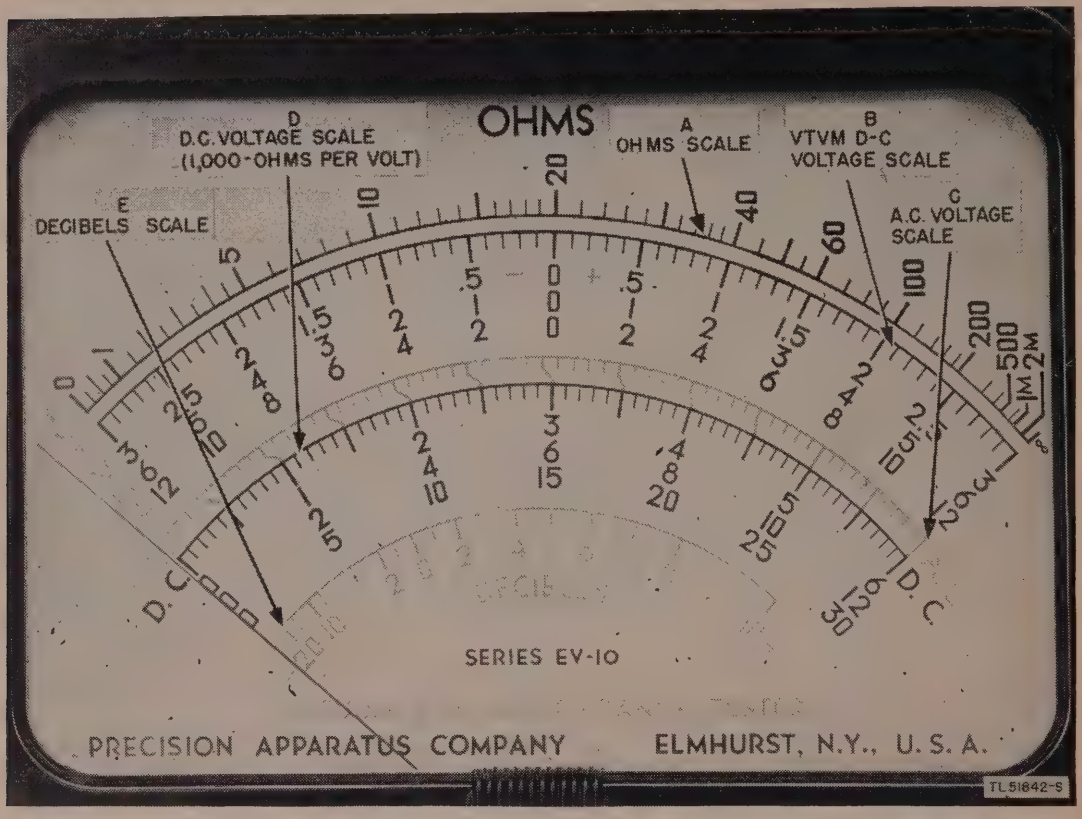

Figure 4. Meter Scales.

Section III. PREOPERATIONAL PROCEDURES

9. Starting Vacuum Tube Voltmeter (figs. 2 and 4)

Before using the equipment, carefully read the operating instructions (part two). The components are delicate electrical instruments and must be handled with care. *Pay particular attention to all cautions;* they are inserted to guide the user and to protect the equipment. Check the over-all operation by following the procedure outlined below. *If any abnormal results are obtained, see section X.*

a. STEP 1. Rotate the CIRCUIT SELECTOR switch to V.T.V.M. OHMS.

b. STEP 2. Rotate the OHMS ZERO CHECK switch to LINE OFF.

c. STEP 3. Set the master-range selector switch at the 3V. position.

d. STEP 4. Make certain that the meter pointer rests at the zero setting on the A.C. or D.C. scale of the meter (zero on scales C or D in fig. 4). If it does not, adjust the zero-set screw on the meter case.

Caution: Never make this adjustment unless the OHMS ZERO CHECK switch is first rotated to the LINE OFF position.

e. STEP 5. Rotate the V.T.V.M. ZERO ADJUST control knob to the arrowhead marked R.

f. STEP 6. Connect the plug of the a-c line cord to a 110- to 120-volt, 50- to 60-cycle a-c power source.

g. STEP 7. Rotate the OHMS ZERO CHECK switch to ON.

(1) The white pilot light, which is located directly under the meter case, will glow.

(2) Watch the meter for approximately 1 minute. During this time the pointer will slowly move along the scale. After the minute has elapsed, the pointer will remain at or within a few divisions of center-scale zero (zero on scale B in fig. 4). If it does not, see *h* below.

Caution: If the pointer remains off scale for more than 30 seconds, it indicates trouble. Immediately rotate the OHMS ZERO CHECK switch to LINE OFF and see section X.

h. STEP 8. Rotate the V.T.V.M. ZERO ADJUST control if necessary, to bring the meter pointer to center-scale zero. Clockwise rotation of control causes the pointer to swing to the right; counterclockwise rotation causes the pointer to swing to the left.

Note. When test leads are connected, see that their terminals are not shorted, or a center-zero setting may not be obtained. Never touch leads with fingers when making this adjustment.

i. STEP 9. Rotate the master-range selecter switch to each of the other five voltage ranges (6V., 12V., 60V., 300V., and 600V.). The meter pointer will remain within one division of its center-zero setting on any voltage range.

j. STEP 10. Rotate the master-range selector switch to the 2,000 MEGS. position, and then to the other resistance ranges. The meter pointer will swing to the right, or off scale to the right, on all ranges.

k. STEP 11. Rotate the OHMS ZERO ADJUST control until the meter pointer rests at the infinity mark (00) on the OHMS scale (00 on scale A in fig. 4).

l. STEP 12. Rotate the OHMS ZERO CHECK switch to OHMS CHECK position. The meter pointer will swing to the left and within a few divisions of the zero mark on the OHMS scale of the meter. While holding the switch in the OHMS CHECK position, adjust the V.T.V.M. ZERO ADJUST control until the meter pointer rests at the zero mark on the OHMS scale.

m. STEP 13. Repeat Steps 11 and 12 above until the meter pointer rests at the infinity mark of the OHMS scale when the OHMS ZERO CHECK switch is released; and at the 0 mark of the OHMS scale when the switch is held in the OHMS CHECK position.

Note. Once set, these adjustments will serve the five highest resistance ranges. The low range (2,000 ohms) may require slight readjustments because the internal battery resistance affects the low-ohm range.

n. STEP 14. Rotate the CIRCUIT SELECTOR switch to the AC. V.-DB. position. The meter pointer will return to the zero mark on the A.C. or D.C. scale (zero on scales C and D in fig. 4).

Section IV. OPERATION

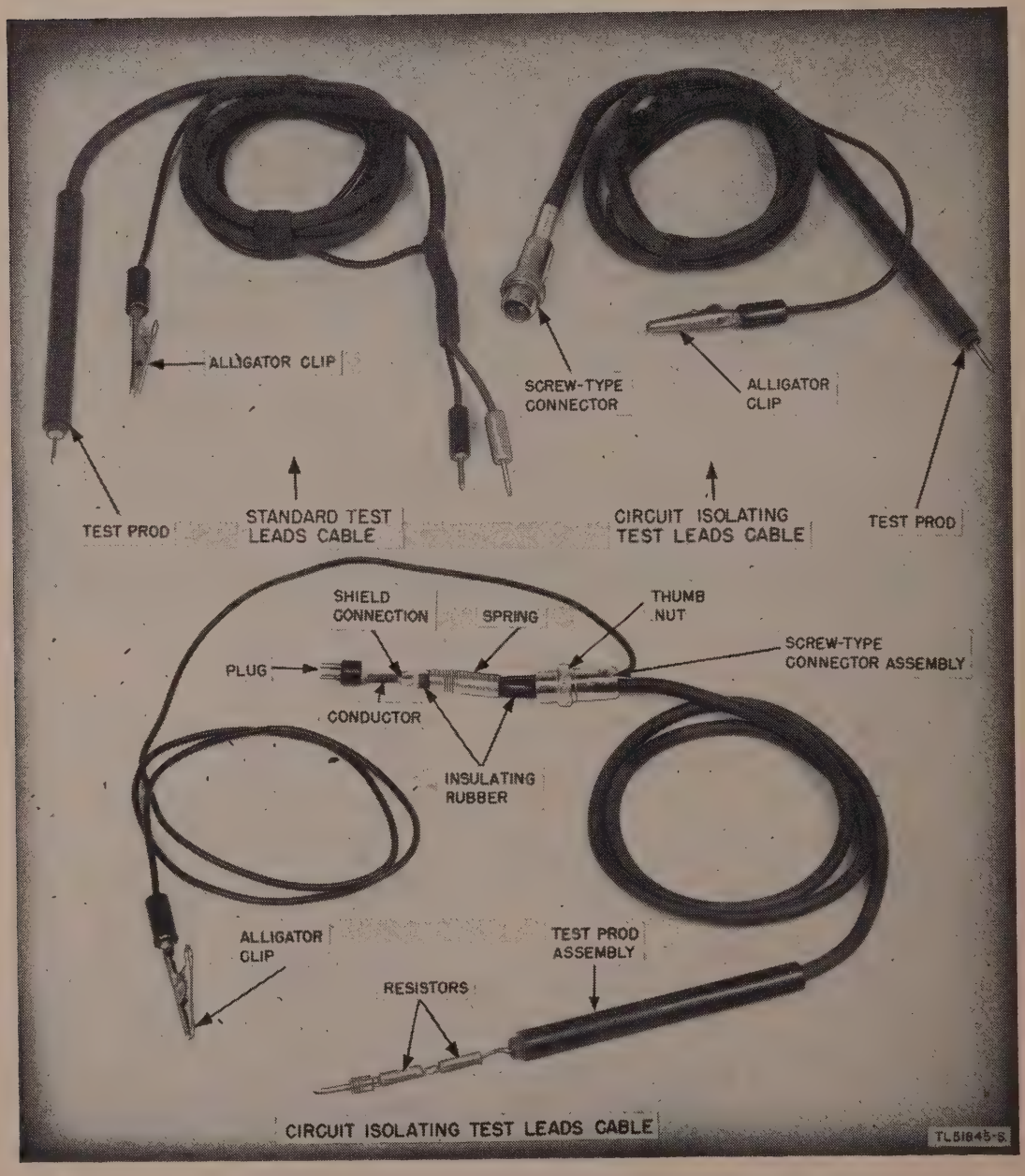

Figure 5. Test leads.

10. General Operating Precautions

a. Check the a-c power source for correct voltage and frequency rating (110/120 volts, 50/60 cycles) before inserting the a-c line cord.

b. Do not remove the a-c line cord from its socket by pulling on the cord. Grasp the plug with the fingers.

c. Make sure that the test leads are inserted into the proper jacks before performing any tests.

d. See that all switches are in the proper positions for each test. If approximate voltage or current to be measured is unknown, start by setting the master-range selector switch on the highest range position, then gradually rotate the switch to the lower settings.

e. Do not remove test leads from the instrument when they are connected to circuits carrying high current. An arc may result which can damage the pin jack contacts.

f. Observe the proper polarity on all tests except VTVM measurements.

g. Do not subject the meter to severe jarring or vibration. The meter movement is fragile.

h. Place the instrument where it will not fall; where it will not be struck by other objects; and where it will not be exposed to moisture or dirt.

i. Rubber-covered cords must not come in contact with gasoline, oil, or other petroleum products, or deterioration of the rubber may occur.

j. Turn off the power and remove the a-c line cord when the instrument is not in use.

k. Never force a large plug into a small pin jack.

11. Controls (fig. 2)

a. Circuit Selector Switch. The 3-position selector switch marked CIRCUIT SELECTOR, in conjunction with the master-range selector switch, provides a simplified means of selecting the type of measurements the operator chooses to perform with the multi-range tester.

Note. The multirange tester will not measure a-c voltage with the CIRCUIT SELECTOR switch in the V.T.V.M. OHMS position unless a vacuum tube probe, incorporating a miniature Tube JAN-9002, is used. This probe is not normally supplied.

b. Master-Range Selector Switch. The range for the particular type of measurement to be made is chosen on the center 12-position master-range selector switch. Each position corresponds to one of two ranges dependent upon the type of measurement selected. For example, if the CIRCUIT SELECTOR is set to DC. V. MA., the outside markings of the master-range selector switch apply. When the CIRCUIT SELECTOR

is set to the AC. V.-DB. position, the left-inside and left-outside markings of the master-range selector switch apply. With the CIRCUIT SELECTOR in the V.T.V.M. OHMS position, the left-outside markings and the right-inside markings of the master-range selector switch apply.

c. OHMS ZERO CHECK SWITCH. The OHMS ZERO CHECK is a special type 3-position selector switch. In positions LINE OFF and ON, it acts as the a-c power switch for the VTVM circuit. In the third position marked OHMS CHECK, the switch performs the function of shorting the ohmmeter test leads for ohms zero adjustment purposes; and does *not* turn off the a-c power to the VTVM circuit. This switch has a built-in spring which automatically returns the switch to ON when the knob is released from the OHMS ZERO position.

d. OHMS ZERO ADJUST CONTROL. The OHMS ZERO ADJUST control is used only when the VTVM megohmmeter circuit is used. The control sets the meter pointer at the infinity mark (00) on the OHMS scale (fig. 4A). The method of making this adjustment is explained in paragraph 9.

e. V.T.V.M. ZERO ADJUST CONTROL. The control marked V.T.V.M. ZERO ADJUST adjusts the meter pointer to zero on the VTVM voltage scale for voltage measurements (fig. 4B), or to zero on the OHMS scale for resistance measurements (fig. 4A). (See par. 9 and 13*a*.)

f. MECHANICAL ZERO-SET ADJUSTMENT. The mechanical zero-set screw on the meter case is used to adjust the meter pointer to zero on the scales marked A.C. and D.C. when the equipment is not in use. (See par. 9*d*.)

12. Precautions for Testing High-voltage Circuits

Certain precautions must be observed when measuring voltages above a few hundred volts. High voltages are dangerous and can be fatal. When it is necessary to measure high voltages, observe the following rules:

a. Connect the ground lead to the voltmeter.

b. Place one hand in the pocket. This will eliminate the possibility of making accidental contact with either ground or another part of the circuit, and causing the electricity to travel from one hand to the other.

c. When voltages to be measured are greater than 200 to 300 volts, turn off the power before making any test connections. After the power has been turned off, proceed with the tests as follows:

(1) Connect the test leads to the proper terminals on the meter.

(2) Connect the opposite ends of the test leads to the points at which the voltage test is to be made.

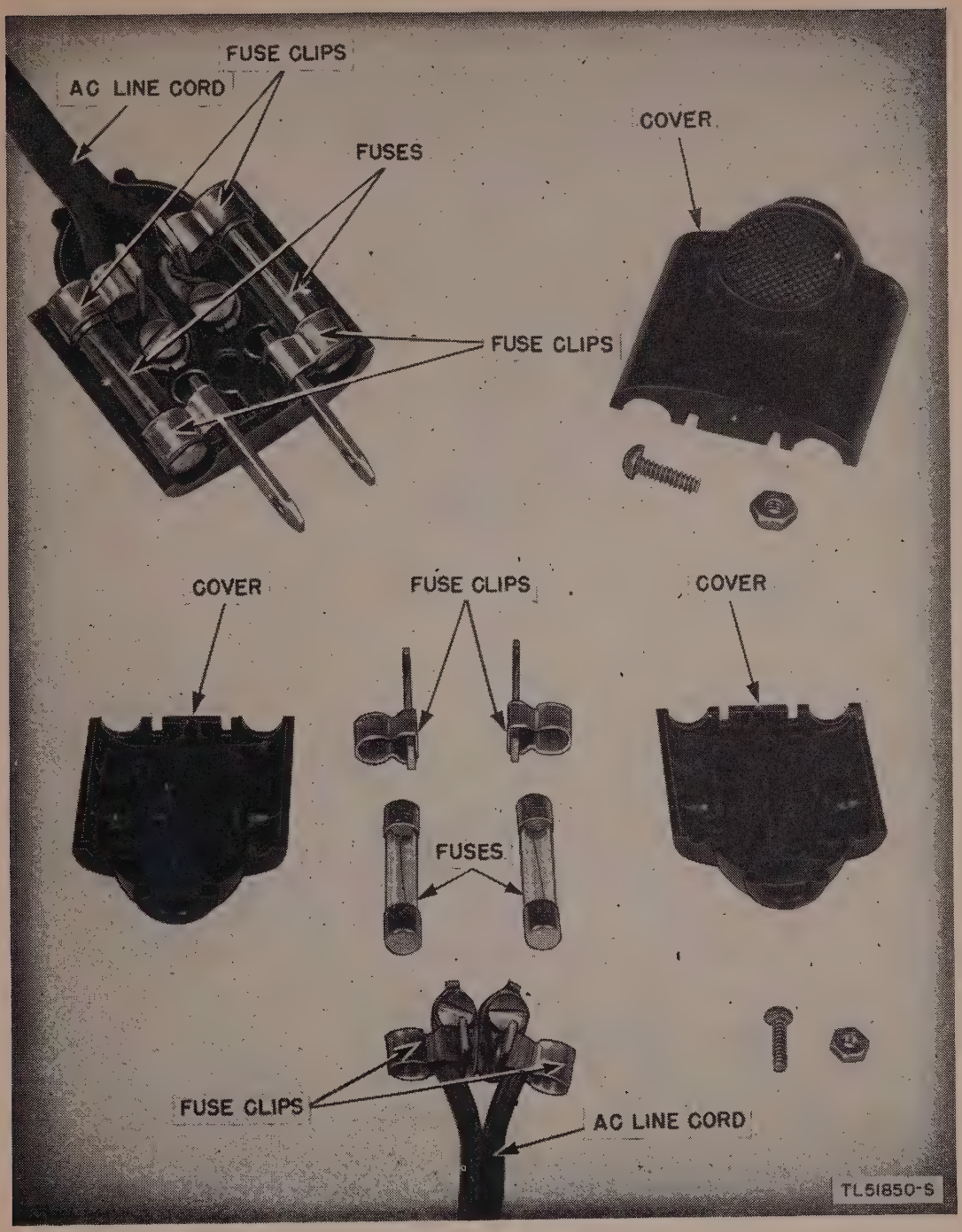

Figure 6, Line cord plug.

(3) Step away from the voltmeter and leads, turn on the power and note the reading of the voltmeter. Do not touch any part of the voltmeter or leads during the period the power is turned on.

(4) When the reading has been noted or the test completed, turn off the power before removing any connections.

Caution: Use only high-voltage test leads for voltages over 600 volts.

13. D-c Voltage Measurements

D-c voltage is measured with the CIRCUIT SELECTOR switch in either the V.T.V.M. OHMS or DC. V. MA. positions. In the V.T.V.M. OHMS position, the circuit input resistance from 3 to 600 volts is approximately 14 megs. The input resistance on the 1,200-volt range is approximately 28 megs, and on the 6,000-volt range approximately 134 megs. These high values of input resistance prevent any appreciable loading of the circuit under test. With the CIRCUIT SELECTOR switch in the DC. V. MA. position, however, the input resistance is only 1,000 ohms per volt. Thus, when measurements are being made, a loading is imposed which may change the voltage of a critical circuit.

a. V.T.V.M.-OHMS Position. (1) Perform steps 1 through 9 of the starting procedure given in paragraph 9.

(2) Connect the standard test leads to the GND. and ± V.T.V.M. TESTS pin jacks on the V.T.V.M.-OHMS panel (fig. 2) for the range of voltages covered by the master-range selector switch (up to 600 volts). When connecting the leads, insert the red phone tip of the test leads to the ± V.T.V.M. TESTS pin jack and the black phone tip to the GND. pin jack.

(*a*) For the 1,200-volt range, the red tip of the high-voltage test lead is plugged into the red 1200V. pin jack on the V.T.V.M.-OHMS panel, and the black tip is plugged into the GND. pin jack. The master-range selector switch must be set at the 600V. position on the 1200V. range. Readings are taken on the VTVM 0 to 12 scale (0-12 scale B in fig. 4) and multiplied by 100.

(*b*) *For the 6000-volt range, use only high voltage test leads.* The black tip of the test lead plugs into the GND. terminal and the red tip plugs into the red 6000V. tip jack on the V.T.V.M.-OHM panel. The master-range selector switch must be set at the 600V. position whenever the 6000V. range is used. Readings are taken on the VTVM 0 to 6 scale (0-6 scale B in fig. 4) and multiplied by 1,000.

(3) The meter is now ready to measure d-c voltages. It is not necessary to observe polarity as zero voltage is in the center of the scale.

(4) In some cases, it is preferable to use the circuit isolating probe to prevent disrupting tuned signal sections, such as the grids of radio frequency (rf), intermediate frequency, (if) and audio amplifiers. This probe is used only for voltage ranges from 3 to 600 volts.

(5) The d-c voltage measurements chart (VTVM) shows the position to selector switches, the test lead terminals, and the meter scale, as well as the meter reading multiplication factor which must be used for each of the VTVM d-c voltage ranges.

D-c Voltage Measurements Chart (VTVM)

Voltage range	CIRCUIT SELECTOR	Master-range selector switch	Test lead terminals	Meter scale (scale B in fig. 4)	Multiplication factor
0-3	V.T.V.M. OHMS	3V.	V.T.V.M. TESTS or V.T.V.M. PROBE	0-3	1
0-6	V.T.V.M. OHMS	6V.	V.T.V.M. TESTS or V.T.V.M PROBE	0-6	1
0-12	do	12V.	do	0-12	1
0-60	do	60V.	do	0-6	10
0-300	do	300V.	do	0-3	100
0-600	do	600V.	do	0-6	100
0-1200	do	600V.	+1200V. and GND. on V.T.V.M.-OHMS panel.	0-12	100
0-6000	do	600V.	+600 V. and GND. on V.T.V.M.-OHMS panel.	0-6	1,000

b. DC. V. MA. POSITION (1,000 OHMS PER VOLT). Unlike the V.T.V.M.-OHMS measurement, this set of measurements does not require connection to an a-c power source and the meter pointer is not zero-centered. Instead, the conventional left zero on the meter is used. The pin jacks under the label AC-DC. VOLTS-DB.-MA. are also used. This method of measuring d-c voltage is as follows:

(1) Set CIRCUIT SELECTOR to DC. V. MA. position.

(2) Set the master-range selector switch to one of the selected voltage ranges.

(3) Check to see if the pointer reads zero. If not, set it at zero by adjusting the mechanical zero-set screw on the meter (par. 9*d*).

(4) When using the 3- to 600-volt ranges, connect the black tip of the test leads to the — pin jack and the red tip of the test leads to the + pin jack on the AC-DC. VOLTS-DB.-MA. panel. These two pin jacks are labeled EXTERNAL TESTS.

(*a*) For the 1,200-volt range, plug the red tip of the high-voltage test lead into the red +1200V. pin jack on the AC-DC. VOLTS-DB.-MA. panel.

(*b*) For the 6,000-volt range, plug the red tip of the high-voltage test lead into the red +6000V. pin jack on the AC-DC. VOLTS-DB.-MA. panel.

Note. Only high voltage test leads should be used on the 6000V. range. When the 1200V. or the 6000V. range is used, the master-range selector switch should be in the 600V. position. Correct polarity must be observed in making these measurements.

(5) The readings are indicated on the meter scales marked D.C. (Scale D in fig. 4).

(6) The d-c voltage measurements chart (1,000-ohms per volt) shows the position of the selector switches, the test lead terminals, and the meter scale, as well as the meter reading multiplication factor which must be used for each of the 1,000 ohms per volt d-c voltage ranges.

D-c Voltage Measurements Chart (1,000-ohms per Volt)

Voltage range	CIRCUIT SELECTOR	Master-range selector switch	Test lead terminals	Meter scale (scale D in fig. 4)	Multiplication factor
0-3	DC. V. MA.	3V.	EXTERNAL TESTS	0-30	0.1
0-6	do	6V.	do	0-6	1
0-12	DC. V. MA.	12V.	EXTERNAL TESTS	0-12	1
0-60	do	60V.	do	0-6	10
0-300	do	300V.	do	0-30	10
0-600	do	600V.	do	0-6	100
0-1200	do	600V.	+1200V. and — on AC-DC. VOLTS-DB.-MA. panel	0-12	100
0-6000	do	600V.	+6000V. and — on AC-DC. VOLTS-DB.-MA. panel	0-6	1,000

14. A-c Voltage Measurements (1,000 ohms per volt)

A-c voltages at frequencies up to 7,000 and 8,000 cycles per second may be measured with this meter. The accuracy of the instrument decreases rapidly as the frequency increases above 7,000 to 8,000 cycles. For normal application, the input impedance may be considered to be 1,000 ohms multiplied by the voltage range used (that is, 300,000 ohms when using the

300 volt range). These measurements require no connection to an external a-c power source. Use the following steps in making a-c voltage measurements.

a. Set the CIRCUIT SELECTOR switch at the AC. V.-DB. position

b. Set the master-range selector switch at the desired voltage range.

c. Check to see if pointer reads zero. If not, set to zero by adjusting the mechanical zero-set screw on the meter (par. 9*d*).

d. Plug the test lead tips into the proper jacks on the AC.-DC.-VOLTS-DB.-MA. panel.

(1) For the 3V. to 600V. ranges, use the — and + jacks.

(2) For the 1200V. range, use the — and +1200V. jack.

(3) For the 6000V. range, use the — and +6000V. jack.

Note. Only high voltage test leads should be used when measuring high voltages on the 6000V. range.

e. The readings are indicated on the meter scales marked A.C. (scale C in fig. 4).

f. The a-c voltage measurements chart shows the position of the selector switches, the test lead terminals, and the meter scale, as well as the meter reading multiplication factor which must be used for each of the 1,000 ohms per volt a-c voltage ranges.

A-c Voltage Measurements Chart

Voltage range	CIRCUIT SELECTOR	Master-range selector switch	Test lead terminals	Meter scale (scale C in fig. 4)	Multiplication factor
0-3	AC. V.-DB	3V.	EXTERNAL TESTS	0-30	0.1
0-6	do	6V.	do	0-6	1
0-12	do	12V.	do	0-12	1
0-60	do	60V.	do	0-6	10
0-300	do	300V.	do	0-30	10
0-600	do	600V.	do	0-6	100
0-1200	do	600V.	+1200V. and — on AC-DC. VOLTS-DB.-MA. panel	0-12	100
0-6000	do	600V.	+6000V. and — on AC-DC. VOLTS-DB.-MA. panel	0-6	1,000

15. Decibel Measurements

The voltmeter incorporates a direct reading and calibrated DECIBELS scale (scale E in fig. 4). Readings from —26 to +70 db may be taken. This measurement reads the db level across 500 ohms with 6 milliwatts (mw) as 0 db. In taking these db measurements make certain that the circuit across which the meter is placed *is isolated from all direct current.* Otherwise, the meter and rectifier may be damaged and the readings will be inaccurate. The frequency of the voltage should not exceed 8,000 cycles for the same reason as explained in paragraph 14. For best results, the frequency should be held constant during the measurement. The following procedure is used for measuring db level:

a. Set CIRCUIT SELECTOR switch to the AC. V.-DB. position.

b. Select suitable DECIBEL range on master-range selector switch.

c. Make connections from across 500-ohm load to EXTERNAL TESTS pin jacks on the right-hand panel.

d. Use the +1200V. pin jack for the 46 db range and the +6000V. tip jack for the 60 db range, with master-range selector switch at the +40DB position.

Note. Decibel measurements and a-c voltage measurement procedures are identical except for the manner in which readings are taken.

e. Read the db level on the DECIBELS scale using the following table.

Range	Procedure
—6DB	Read on DECIBELS scale —20 to +10 and subtract 6 db.
0DB	Read on DECIBELS scale —20 to +10.
+6DB	Read on DECIBELS scale —20 to +10 and add + 6 db.
+20DB	Read on DECIBELS scale —20 to +10 and add +20 db.
+34DB	Read on DECIBELS scale —20 to +10 and add +34 db.
+40DB	Read on DECIBELS scale —20 to +10 and add +40 db.
+46DB	Read on DECIBELS scale —20 to +10 and add +46 db.
+60DB	Read on DECIBELS scale —20 to +10 and add +60 db.

Note. The meter scale reading —20 to +10 db is based upon a zero level of 6 mw or 1.73 volts across a 500-ohm load. Because of calibration at one definite impedance, conversions must be made to the new impedance when used at oher than 500 ohms. See decibel conversion table in figure 7 for interpretations of decibel readings in terms of power, power ratios, voltage and voltage ratios.

DECIBEL CONVERSION CHART

Power Level DB	Power Ratio to 0 DB	Power 006 Watt at 0 DB Watts	Voltage Ratio to 0 DB	Volts—Based on 006 Watt at 0 DB in	
				500 ohms	600 ohms
—10	0.1000	0.0006000	0.31623	0.5477	.6000
— 9	0.1259	0.0007553	0.35481	0.6145	.6732
— 8	0.1585	0.0009509	0.39811	0.6895	.7554
— 7	0.1995	0.0011972	0.44668	0.7737	.8475
— 6	0.2512	0.0015071	0.50119	0.8681	.9509
— 5	0.3162	0.0018975	0.56234	0.9740	1 0670
— 4	0.3981	0.0023886	0.63096	1.0928	1.1972
— 3	0.5012	0.0030071	0.70795	1.2262	1.3433
— 2	0.6310	0.0037857	0.79433	1 3758	1.5071
— 1	0.7943	0.0047660	0.89125	1.5437	1.6910
0	1.0000	0.0060000	1.00000	1.7321	1.8974
+ 1	1.2589	0.0075535	1 1220	1.9434	2.1289
+ 2	1.5849	0.0095093	1.2589	2.1805	2.3886
+ 3	1.9953	0.0119716	1.4125	2.4466	2.6801
+ 4	2.5119	0.0150713	1.5849	2.7451	3.0071
+ 5	3.1623	0.0189747	1.7783	3.0801	3.3741
+ 6	3.9811	0.0238865	1.9953	3.4559	3.7867
+ 7	5.0119	0.030071	2.2387	3.8776	4.2477
+ 8	6.3096	0.037857	2 5119	4.3507	4 7660
+ 9	7.9433	0.047660	2.8184	4.8816	5 3475
10	10.0000	0.060000	3.1623	5.4772	6 0000
11	12 589	0.075535	3.5481	6.1455	6.7321
12	15.849	0.095093	3.9811	6.8954	7.5536
13	19.953	0.119716	4.4668	7.7368	8.4752
14	25.119	0.150713	5.0119	8 6808	9.5094
15	31.623	0.189747	5.6234	9.7400	10.670
16	39.811	0.238865	6.3096	10.9285	11.972
17	50.119	0.30071	7.0795	12.2620	13.433
18	63.096	0.37857	7.9433	13.7582	15.071
19	79.433	0.47660	8.9125	15.4369	16.910
20	100.000	0.60000	10.0000	17.3205	18 974
21	125.89	0.75535	11.220	19.434	21.289
22	158.49	0.95093	12.589	21.805	23.886
23	199.53	1.19716	14.125	24.466	26.801
24	251.19	1.50713	15.849	27.451	30.071
25	316.23	1.89747	17.783	30.801	33.741
26	398.11	2.38865	19.953	34.559	37.867
27	501.19	3.0071	22.387	38.776	42.477
28	630.96	3.7857	25.119	43.507	47.660
29	794.33	4.7660	28.184	48.816	53.475
30	1000.00	6.0000	31.623	54.772	60.000
31	1258.9	7.5535	35.481	61.455	67.321
32	1584.9	9.5093	39.811	68.954	75.536
33	1995.3	11.9716	44.668	77.368	84.752
34	2511.9	15.0713	50.119	86.808	95.094
35	3162.3	18.9747	56.234	97.400	106.70
36	3981.1	23.8865	63.096	109.285	119.72
37	5011.9	30.071	70.795	122.620	134.33
38	6309.6	37.857	79.433	137.582	150.71
39	7943.3	47.660	89.125	154.369	169.10
40	10000.0	60.000	100.000	173.205	189.74
41	12589.2	75.535	112.20	194.34	212.89
42	15848.9	95.093	125.89	218.05	238.86
43	19952.6	119.716	141.25	244.66	268.01
44	25118.9	150.713	158.49	274.51	300.71
45	31622.8	189.747	177.83	308.01	337.41
46	39810.7	238.865	199.53	345.59	378 67
47	50118.7	300.71	223.87	387.76	424 77
48	63095.7	378.57	251.19	435.07	476.60
49	79432.7	476.60	281.84	488.16	534.75
50	100000.0	600.00	316.25	547 72	600.00

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Figure 7. Decibel conversion chart.

16. Output Meter Indications

The OUTPUT pin jack is used to block out the d-c component of an a-c voltage during output tests. The CIRCUIT SELECTOR and master-range selector switch settings are the same as for a-c voltage measurements (par. 14). For the 3- to 600-volt range, plug one test lead tip into the — EXTERNAL TESTS jack and the other test lead tip into the OUTPUT jack. The voltage appearing at the points across which the output measurements are taken should never be in excess of 600 volts peak when the OUTPUT jack is used. For higher output voltage tests, use the +1200V. and +6000V. jacks instead of the OUTPUT jack with capacitors connected in series with the test lead. Use a 0.1-microfarad (mf) 600 V.W.V. series capacitor for the +1200V. range and a 0.011-mf, 5,400 V.W.V. series capacitor for the +6000V. range.

Note. Capacitor voltages are direct current working voltages.

17. Resistance Measurements

To operate the megohmmeter proceed as follows:

a. Perform steps 1 through 13 of the starting procedure given in paragraph 9.

b. Connect the black phone tip of the standard test leads to the SHIELD pin jack, and the red phone tip to the HIGH pin jack.

c. The instrument is now ready to measure resistance. Readings are taken on the top OHMS scale and multiplied by the multiplication factor which is marked for each range on the master-range selector switch. For example, if a meter reading of 10 is obtained when using the 2000-ohm range, the resistance will be R x 1 = 10 x 1 = 10 ohms. If, however, the same reading were obtained when using the 20 MEGS. range, the resistance would be R x 10,000 = 10 x 10,000 = 100,000 ohms.

18. D-c Current Measurements

D-c current measurements do not require any external a-c power source because the VTVM circuit is not used for current measurement.

a. Set the CIRCUIT SELECTOR switch at DC. V. MA. position.

b. Select the proper current range on the master-range selector switch.

c. Plug the test leads into the EXTERNAL TESTS pin jacks (black phone tip in the — pin jack and red phone tip in the + pin jack).

Note. The 12-ampere range has a separate set of tip jacks marked 12 AMPS. When using these jacks, set the master-range selector switch to the 1200 MA. position. When using the 12 AMP. range, never remove pins from jacks while current is flowing through the circuit. Failure to observe this will result in damage to the pin jacks.

d. Place test leads in series with the current to be measured and read the value on the D.C. meter scale (scale D in fig. 4).

e. The following chart shows the setting of selector switches, the test lead terminals, and the meter scale, together with the meter reading multiplication factor which must be used for each of the d-c current ranges.

D-c Current Measurements Chart

Current range	CIRCUIT SELECTOR	Master-range selector switch	Test lead terminals	Meter scale (scale D in fig. 4)	Multiplication factor
0-0.6 ma	DC.V.MA.	.6MA.	EXTERNAL TESTS	0-6	0.1
0-3 ma	do	3MA.	do	0-30	0.1
0-12 ma	do	12MA.	do	0-12	1
0-60 ma	do	60MA.	do	0-6	10
0-300 ma	do	300MA.	do	0-30	10
0-1200 ma	do	1200MA.	do	0-12	100
0-12 amp	do	1200MA.	12 AMPS.	0-12	1

PART THREE

MAINTENANCE INSTRUCTIONS

Section V. PREVENTIVE MAINTENANCE TECHNIQUES

19. Meaning of Preventive Maintenance

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment, when turned off, to eliminate major break-downs and unwanted interruptions in service, and to keep the instrument operating at top efficiency. To understand what is meant by preventive maintenance, it is necessary to distinguish between preventive maintenance, trouble shooting, and repair. The prime function of preventive maintenance is to *prevent* break-downs and, therefore, the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct *existing* defects. The importance of preventive maintenance cannot be overemphasized. The entire system of communications depends upon the readiness and operating efficiency of each item of equipment when it is needed. In a similar manner, the test equipment by which this condition of readiness in communications equipment is realized, must be kept in excellent operating condition at all times.

Note. The operations in sections V and VI are user maintenance operations.

20. Description of Preventive Maintenance Techniques

a. GENERAL. Most of the electrical parts used in the multi-range tester require routine preventive maintenance. However, not all parts require the same maintenance, and some parts require more than others. Because hit-or-miss maintenance techniques must not be used, specific instructions are provided. This section of the manual contains these specific instructions and serves as a guide for personnel assigned to perform the six basic maintenance operations. These operations are: Feel, Inspect, Tighten, Clean, Adjust, and Lubricate. Throughout this manual the lettering system for the six operations will be as follows:

F—Feel.
I—Inspect.
T—Tighten.
C—Clean.
A—Adjust.
*L—Lubricate.

*The Lubricate operation is inapplicable to this instrument.

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field needs. For example, the dust encountered on dirt roads during cross-country travel filters into the equipment no matter how much care is taken to prevent it. Rapid changes in weather (such as heavy rain followed by blistering heat), excessive dampness, snow, and ice tend to cause corrosion of exposed surfaces and parts. Without frequent inspections and the necessary performance of tightening, cleaning, and lubricating operations, equipment becomes undependable and subject to break-down when it is most needed.

b. FEEL. The feel operation is used most often to check rotating machinery, such as blower motors, drive motors, etc., and to determine if electrical connections, bushings, etc., are overheated. The use of the feel operation on this equipment is confined, however, to checking the temperature of the power transformer.

Note. It is important that the feel operation be performed as soon as possible after shut-down and always before any other maintenance is done.

c. INSPECT. Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook evidences of minor trouble. Although these defects may not interfere with performance of the equipment, valuable time and effort may be saved if they are corrected *before* they lead to major break-downs. Make every effort to become thoroughly familiar with indications of *normal* functioning, to be able to recognize the signs of a defective set. Inspection consists of carefully observing all parts of the equipment, noticing their color, placement, state of cleanliness, etc. Inspect for the following conditions:

(1) Overheating, as indicated by discoloration, blistering, or bulging of the parts or surface of the container; leakage of insulating compounds; and oxidation of metal contact surfaces.

(2) Placement, by observing that all leads and cabling are in their original positions.

(3) Cleanliness, by carefully examining all recesses in the units for accumulation of dust, especially between connecting terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

(4) Tightness, by testing any connection or mounting which appears to be loose.

d. TIGHTEN, CLEAN, AND ADJUST. These operations are self-explanatory. Specific procedures to be followed in performing them are given wherever necessary throughout part three.

Caution: Screws, bolts, and nuts should not be tightened carelessly. Fittings, tightened beyond the pressure for which they are designed will be damaged or broken.

Whenever a loose connection is tightened, it should be moistureproofed and fungiproofed again by applying the varnish with a small brush. See section VIII for details of moistureproofing and fungiproofing.

21. Vacuum Tubes

Note. Do not work on the tubes immediately after shut-down. Severe burns may result from contact with the envelopes of hot tubes.

a. INSPECT (I). (1) Inspect glass envelopes for corrosion and accumulation of dirt.

(2) Inspect the firmness of tubes in their sockets. Press them down in the sockets and test them in that position. Do not withdraw the tubes part way or jiggle them from side to side. Moving a tube weakens the pins in the base and spreads the socket contacts. Inspect the sockets at the time the tubes are removed.

(3) Do not remove a tube from its socket carelessly. Never jar a tube while it is warm.

b. TIGHTEN (T). Tighten all loose connections to the tube sockets or to the tubes. If the connections are dirty or corroded, clean them first.

c. CLEAN (C). (1) Clean the tubes, but only if inspection shows cleaning is necessary. Remove dust and dirt from the glass envelopes with a clean, lint-free, dry cloth.

(2) When tube sockets are cleaned and the contacts are accessible, fine sandpaper may be used to remove corrosion, oxidation, and dirt.

22. Capacitors

a. INSPECT (I). (1) Inspect the terminals of fixed capacitors for corrosion and loose connections. Carefully inspect the mountings for loose studs or brackets. Examine the leads for poor insulation, for cracks, and for evidences of dry rot. Frayed strands on the insulation should be cut away. If the wire is exposed, wrap it with friction tape. The terminals of the capacitors should not be cracked or broken.

(2) Thoroughly inspect the case af each fixed capacitor for bulges, discoloration, leaking compound, or dripping wax.

b. TIGHTEN (T). Tighten loose terminals, mountings, and connections on the capacitors.

c. CLEAN (C). Remove accumulation of dirt, dust, corrosion, or fungus with a small brush.

23. Resistors

a. GENERAL. The connections to the various resistors are either of the pigtail or solder lug type.

b. INSPECT (I). Examine the bodies of the resistors for blistering, discoloration, and other indications of overheating. Inspect leads and all other connections for corrosion, dirt, dust, looseness, and broken strands in the connecting wires. Check the security of all mountings. Do not move

resistors with pigtail connections, because there is danger of breaking the connections at the point where they enter the body of the resistor. Such defects cannot be repaired.

c. TIGHTEN (T). Keep the resistor connections and mountings tightened. If a resistor is allowed to remain loose, vibration may break the connection or damage the body.

d. CLEAN (C). (1) Clean all carbon resistors with a small brush.

(2) Resistors with discolored bodies cannot be cleaned. Discoloration indicates that there has been overloading and overheating at some time prior to the inspection. The discoloration is probably due to circuit trouble which requires analysis and correction. Trouble-shooting procedures are described in section X.

24. Fuses

a. GENERAL. The two fuses used in the instrument are contained in the plug of the a-c line cord (fig. 6). The glass fuses are easily removed for inspection by pressing a small instrument through the openings in the plug. These openings are near the hole through which the a-c line cord enters the plug. Fuses should be thrown away when they blow. See that the fuse ends and holding clips on the fuses are kept clean and tight. If they are not, arcing and burning will occur and make the replacement of the complete holder necessary.

b. INSPECT (I). Inspect the fuse caps for evidence of burning, charring, and corrosion; inspect the fuse clips for dirt, loose connections, and proper tension.

c. TIGHTEN (T). The tension of the fuse clips may be increased by pressing the sides closer together.

d. CLEAN (C). Clean fuse ends and fuse clips with emery cloth; then wipe them with a clean cloth.

25. Switches

a. INSPECT (I). (1) Inspect the mechanical action of each switch and, while so doing, look for signs of dirt or corrosion on all exposed elements.

(2) Examine ganged switches (S1, S2, and S3) to see if the contacts are clean. Inspection is visual. Do not pry the leaves of the switch apart. The rotary members should make good contact with the stationary members; and as the former slides into the latter, a spreading of the stationary contact leaves should be visible. Switch action should be free. Wiping action of contacts usually removes any dirt at the point of contact.

b. TIGHTEN (T). Tighten mounting nuts, if necessary, with a $\frac{9}{16}$-inch open-end wrench.

c. CLEAN (C). Clean the exterior surfaces of switches with a stiff brush, moistened with dry-cleaning solvent (SD). Do not use any abrasive on the switch contacts because it will remove the plating.

26. Rheostats and Potentiometers

a. INSPECT (I).

Caution: Do not disturb position of sealed controls (R28, R30, R33, and R43).

(1) Inspect the mechanical condition of the rheostats and potentiometers. The arm should be keyed tightly to the shaft, and the shaft should turn easily in the bushing which supports it.

(2) Inspect the assembly and mounting screws, setscrews, and nuts.

(3) Examine all parts for dust, dirt, and corrosion.

b. TIGHTEN (T). Tighten loose assembly or mounting screws.

c. CLEAN (C). Remove accumulation of dirt, dust, corrosion, or fungus with a small brush. If necessary, moisten the brush with dry-cleaning solvent (SD).

27. Terminal Blocks

a. INSPECT (I). (1) Inspect terminal blocks for cracks, breakage, dirt, and loose connections or mounting screws.

(2) Carefully examine connections for mechanical defects, dirt, and corrosion.

b. TIGHTEN (T). Tighten loose screws, lugs, and mounting bolts. When tightening, be sure to select the proper tool; do not exert too much pressure.

c. CLEAN (C). Clean terminal blocks, when they need it, with a dry brush. If necessary, use a cloth moistened with dry-cleaning solvent (SD). If a solvent is used, wipe the block with a cloth and then brush it to remove the lint.

28. Connectors (fig. 5)

A multiple connector and plug connect the circuit isolating test leads cable to the V.T.V.M. PROBE socket.

a. INSPECT (I). Inspect the female ends of the connector for corrosion and collected dust. Inspect the tighteners of the mountings. Inspect the male ends for loose and broken pins.

b. CLEAN (C). Clean the male and female ends of the connectors with a brush moistened in dry-cleaning solvent (SD). Remove corrosion with #0000 sandpaper, then wipe with a clean cloth.

29. Wiring

The wires are the life lines of the equipment. For this reason the condition of the wiring must be closely observed.

a. INSPECT (I). Inspect the wires for cracked or deteriorated insulation, frayed or cut insulation at the connecting and supporting points. See that they are properly placed and do not strain the connections. Also

watch for kinks and improper supports. Look for signs of flash-over (charred spots) in the cables and on the mounting boards. Fungus, grease, or dirt on the wiring or components can cause flash-over on high voltages.

b. TIGHTEN (T). Tighten loose connections. Resolder if necessary. Do not expose the circuit elements to the heat of the iron. It may change their values permanently.

c. CLEAN (C). Clean connections when they are dirty or corroded.

30. Meters

Meters are extremely delicate precision instruments and must be handled very carefully. Ordinarily, they require very little maintenance.

a. INSPECT (I). Inspect the leads and connections of the meters. Look for loose, dirty, and corroded connections. Look for cracked or broken cover glasses. Since the movement of a meter is extremely fragile, its accuracy will be seriously affected if the glass is broken and dirt and water filter through.

b. TIGHTEN (T). Tighten all loose connections. Any loose meter wires should be inspected for dirt or corrosion before they are tightened. The tightening of meter connections requires a special technique because careless handling can easily crack the meter case. Cracked glass may sometimes be temporarily repaired by sealing the crack with transparent tape.

c. CLEAN (C). Meter cases may usually be cleaned with a dry cloth. If cleaning is difficult, the cloth should be dampened with a dry-cleaning solvent (SD). Dirty connections may be cleaned with a small brush dipped in dry-cleaning solvent (SD) or with a small piece of cloth dipped in the solvent.

d. ADJUST (A). Normally, the meter in the multirange tester should indicate zero on the A.C. and D.C. scales (scales C and D in fig. 4) when the equipment is turned off. The procedure for setting a meter to zero is not difficult. The tool required is the thinnest screw driver. Before deciding that the meter needs readjusting, tap the meter case *lightly* with the tip of one finger. This will help the needle to overcome the slight friction which sometimes exists at the bearings and prevents an otherwise normal unit from coming to rest at zero. If adjustment is needed, insert the tip of the screw driver in the slotted screw head located below the meter glass and *slowly* turn the adjusting screw until the pointer is at zero. Lightly tap the meter case again and view the meter face and pointer "full on" and not from either side. Avoid turning the screw too far, because the needle may be bent or the hairspring damaged.

31. Pilot Lamp

The pilot lamp indicates that power has been applied to the VTVM circuit. To replace a pilot bulb, remove the socket by means of a ½-inch open-end wrench and pliers padded with cloth to grasp the jewel.

a. INSPECT (I). Inspect the pilot-lamp assembly to see that the lamp and the mounting nut are tight. Look for loose, dirty, or corroded connections.

b. TIGHTEN (T). (1) Tighten loose mounting nuts and resolder any loose connections. If the connections are dirty or corroded, they should be cleaned before soldering.

(2) A loose lamp should be screwed tightly into the socket.

32. Jacks and Plugs

The pin jacks require very little attention, and then only at infrequent intervals. Inserting and removing the test leads during normal use should keep the jacks and cord tips clean. Occasionally, it will be necessary to clean the contacts or increase the spring tension. Remove the contact by unsoldering the connecting wire and pushing on the terminal end of the contact. Remove dirt with a brush and dry-cleaning solvent (SD); remove corrosion with a piece of crocus cloth followed by a clean cloth. Increase spring tension when necessary. It is recommended that the action of the jack be tried after each adjustment.

33. Batteries and Battery Compartment (fig. 3)

The batteries seldom need to be replaced. However, weak cells should be replaced. When normal, each cell has a voltage rating of 1½ volts.

a. INSPECT (I). Inspect the spring contactor and the contact points between the batteries for corrosion. Examine the two connecting leads for tightness, signs of frayed insulation and dry rot.

b. TIGHTEN (T). Tighten loose connections and mounting boards.

c. CLEAN (C). Clean dirty or corroded contacts with #0000 sandpaper, and wipe dry with a clean cloth. Use a small brush slightly moistened with dry-cleaning solvent (SD) for connections.

d. ADJUST (A). Increase the spring tension, if necessary, by removing the batteries and pulling the spring forward.

34. Cabinets, Chassis, and Mountings

The cabinet which houses the components is constructed of sheet steel, coated with a black crinkle finish.

a. INSPECT (I). Inspect the outside and inside of the cabinet thoroughly, paying strict attention to every detail. Check the rubber mountings, the panel screws, and the zero setting of the meter. Examine the pilotlamp cover for cracks and breaks. Inspect the panel for loose knobs, switches, and jacks.

b. CLEAN (C). Clean the cabinet, outside and in, with a clean, dry cloth. Repaint any surface which is scratched, rusted, or chipped (see par. 64).

c. TIGHTEN (T). Tighten all mounting bolts, panel screws, plugs, and control knobs found loose.

Section VI. ITEMIZED PREVENTIVE MAINTENANCE

35. Introduction

For ease and efficiency of performance, preventive maintenance on the multirange tester is broken down into operations which are to be performed at different time intervals. In this section the preventive maintenance schedule is divided into units of work called items. The general techniques involved and the application of the FITCAL operations on individual parts are discussed in section V. These general instructions are not repeated in this section. When performing preventive maintenance, see section V if more information is required for the following items. All work is done with the power shut off. After preventive maintenance has been performed the equipment should be put into operation and checked for satisfactory performance. (See par. 9.)

36. Preventive Maintenance Tools and Materials

The following materials will be needed in performing preventive maintenance:

Common hand tools.
Clean cloth.
#0000 sandpaper.
Crocus cloth.
Dry-cleaning solvent (SD).
Paste metal-polish (Signal Corps stock No. 6G1516).
Small brush.
Soldering iron and solder.
Open-end wrenches (½ inch, $\frac{9}{16}$ inch, thin).

Note. Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry-cleaning, is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, may be used for cleaning purposes when dry-cleaning solvent (SD) is not at hand. Carbon tetrachloride will be used as a cleaning fluid on electrical wiring or contacts only when prescribed.

37. Item 1, Test Leads

PRELIMINARY STEPS. Remove the test loads from the equipment. Remove the circuit isolating test leads cable connector from the V.T.V.M. PROBE socket. Disassemble the cable connector by removing the two

holding screws from the connector and sliding the connector assembly apart, as shown in figure 5. Unscrew the outer shell of the test prods. One prod contains two small carbon resistors (fig. 5).

OPERATIONS.

ITC Cable connector
ITC Resistors
ITC Prods
ITC Cords
ITC Connections
ITC Phone tips
ITC Alligator clips

REMARKS. Inspect the insulation on the cords for breaks or weak spots. Poor insulation may cause severe shock to the operator and damage to the equipment.

38. Item 2, Interior of Cabinet (figs. 22, 23, and 24)

PRELIMINARY STEPS. Remove the 12 screws on the edge of the front panel and slide the chassis from the cabinet. However, do not pull it out too far, as there are two wires connected between the cabinet and the chassis.

OPERATIONS.

FITC Transformer T1.
ITC Tubes and sockets.
ITC Capacitors.
ITC Resistors.
ITC Rheostats and potentiometers (see CAUTION in par. 26).
ITC Terminals and terminal blocks.
ITC Switches.
ITC Pilot light and socket.
ITCA Meter.
ITC Pin jacks.
ITC V.T.V.M. PROBE socket.
ITC Wiring.
ITC Cabinet and chassis.
ITCA Batteries and battery compartment.

REMARKS: Perform no preventive maintenance on copper-oxide rectifier.

39. Item 3, Exterior of Cabinet

PRELIMINARY STEPS. If necessary, put the chassis back into the cabinet. Be sure that all 12 panel screws are replaced and tightened.

OPERATIONS.

ITC Control knobs.
ITC Pin jacks.
ITC V.T.V.M. PROBE socket.
IT Pilot light jewel.
IC Meter case.
IA Meter zero setting.
IC Panel paint and markings.
IC Cabinet.
ICT Plug on a-c line cord.
ITC Fuses.
ITC Line Cord.

REMARKS. Disassemble the plug on the a-c line cord by removing the holding screw. All parts including the fuses will then be accessible (fig. 6).

40. Preventive Maintenance Check List

The following check list is a summary of the preventive maintenance operations to be performed on the multirange tester. The time intervals shown on the check list may be reduced at any time by the local commander. For best performance of the equipment, perform operations at least as frequently as called for in the check list. The echelon column indicates which operations are first echelon maintenance and which operations are second echelon maintenance. Operations are indicated by the letters of the word FITCAL. For example, if the letters ITC appear in the "Operations" column, the item to be treated must be inspected (I), tightened (T), and cleaned (C).

Item No.	Operations	Item	When performed				
			Daily	Weekly	Monthly	Semi-annually	Echelon
1	ITC	Test loads		X			2d
2	FITC	Interior of cabinet			X		2d
3	ITC	Exterior of cabinet	X				1st

F Feel — I Inspect — T Tighten — C Clean — A Adjust — *L Lubricate

*The Lubricate operation is inapplicable to this instrument.

Section VII. LUBRICATION

(Lubrication for the multirange tester is not required.)

Section VIII. MOISTUREPROOFING AND FUNGIPROOFING

41. General

When operated in tropical areas where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention These are some of the problems met:

a. Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

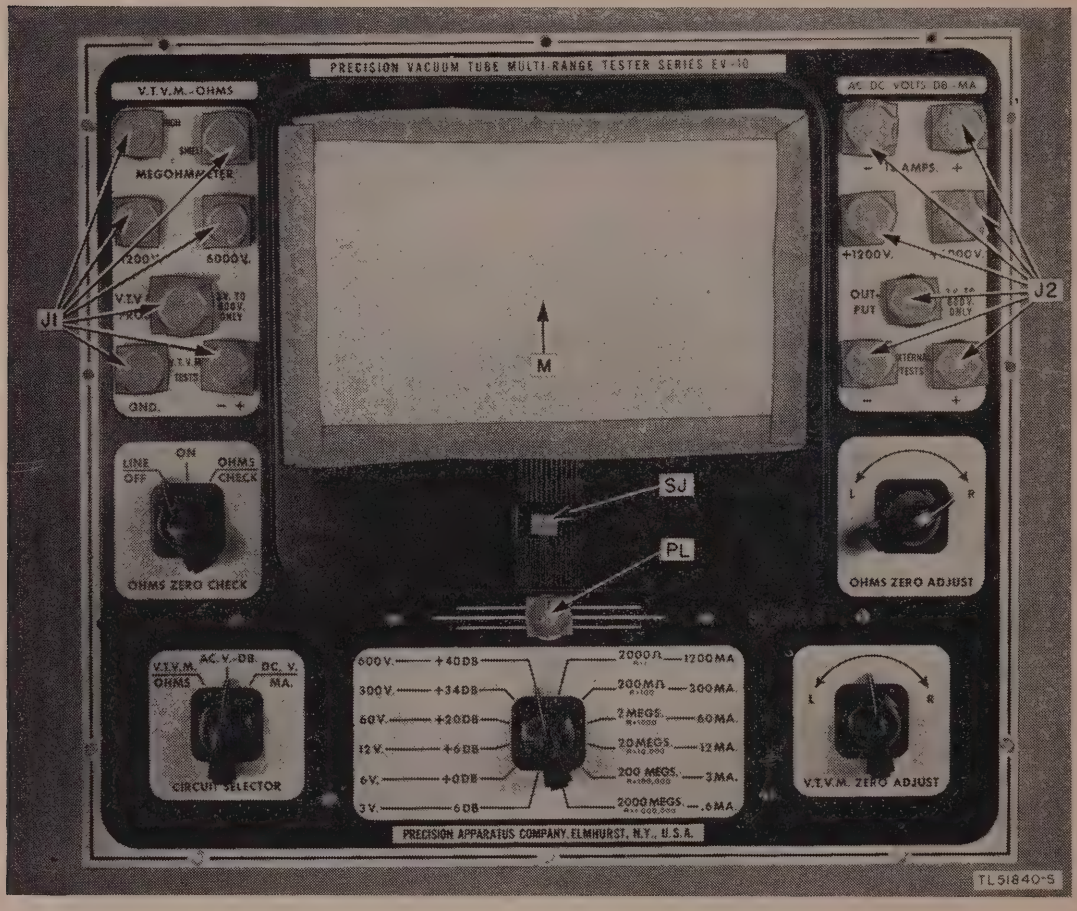


Figure 8. Masking of parts on front panel for moistureproofing and fungiproofing.

b. Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual breakdown.

c. Hook-up wire insulation and cable insulation breakdown. Fungus growth accelerates deterioration.

d. Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs and crosstalk.

e. Moisture provides leakage paths between battery terminals.

42. Treatment

A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. See TB SIG 13 for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

Caution: Varnish spray may have poisonous effect if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth

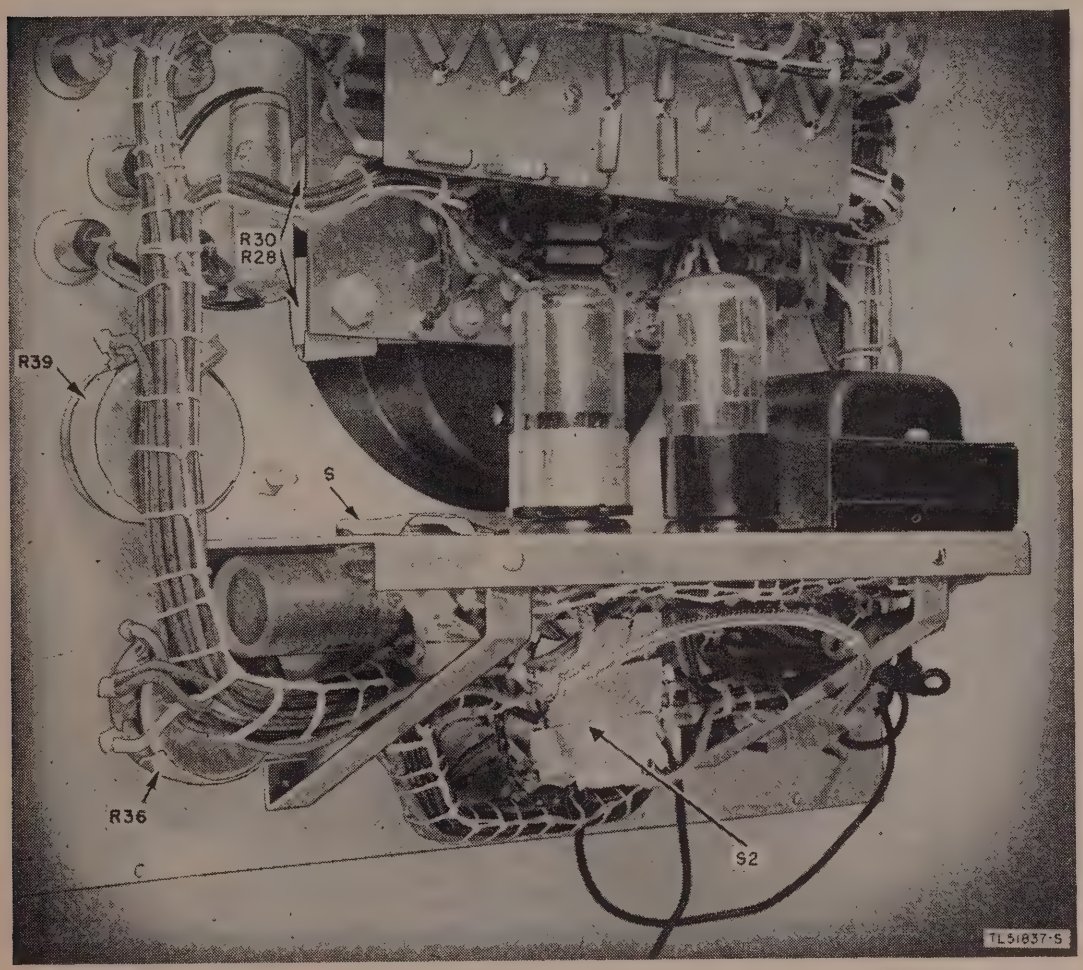


Figure 9. Masking of parts on chassis for moistureproofing and fungiproofing.

or other cloth material over nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

43. Vacuum Tube Voltmeter (Precision Model EV-10-MCP)

a. PREPARATION. Make all repairs and adjustments necessary for proper operation of the equipment.

b. DISASSEMBLY. As equipment is disassembled, all screws, bolts, and

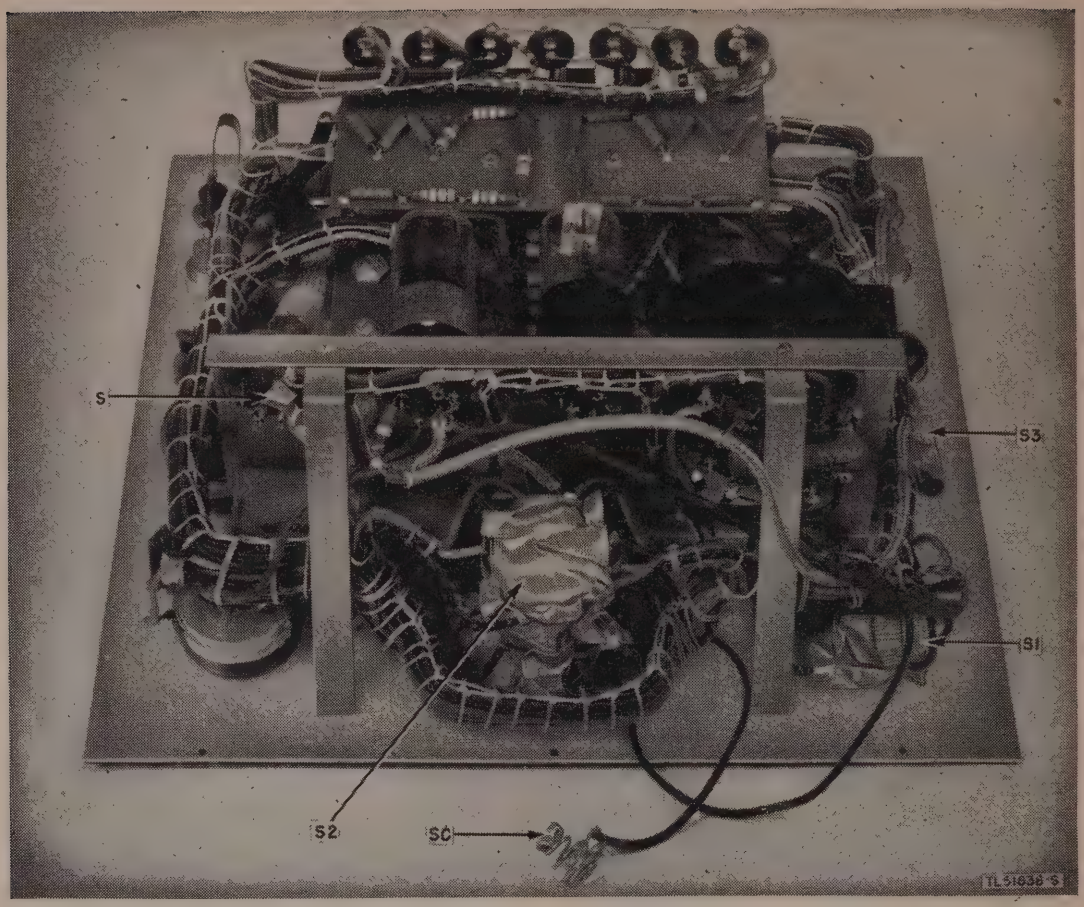


Figure 10. Masking of parts on chassis for moistureproofing and fungiproofing.

nuts should be replaced immediately in their respective holes. This precaution will prevent their loss and keep the threads from clogging during treatment.

(1) Remove 12 screws around the edge of the front panel.

(2) Carefully remove the unit from the cabinet.

(3) Remove a-c line cord by unsoldering the two connections on JAN-OD3/VR-150 tube socket (S in fig. 10), and pull cord out through rear of cabinet.

(4) Remove batteries from the cabinet (B in fig. 12).

(5) Remove battery wire from connection within cabinet by removing spring contact from holding block (HB in fig. 12).

(6) Remove JAN-OD3/VR-150 tube.

(7) Remove lacing where practicable and separate the wires to make it easier for the lacquer to penetrate.

c. Cleaning. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

d. Masking. (1) Mask the six pin jacks and the V.T.V.M. PROBE connector (J1 in fig. 8) in upper left-hand corner of the front panel.

(2) Mask the seven pin jacks (J2 in fig. 8) in upper right-hand corner.

(3) Mask the glass face of the meter (M in fig. 8).

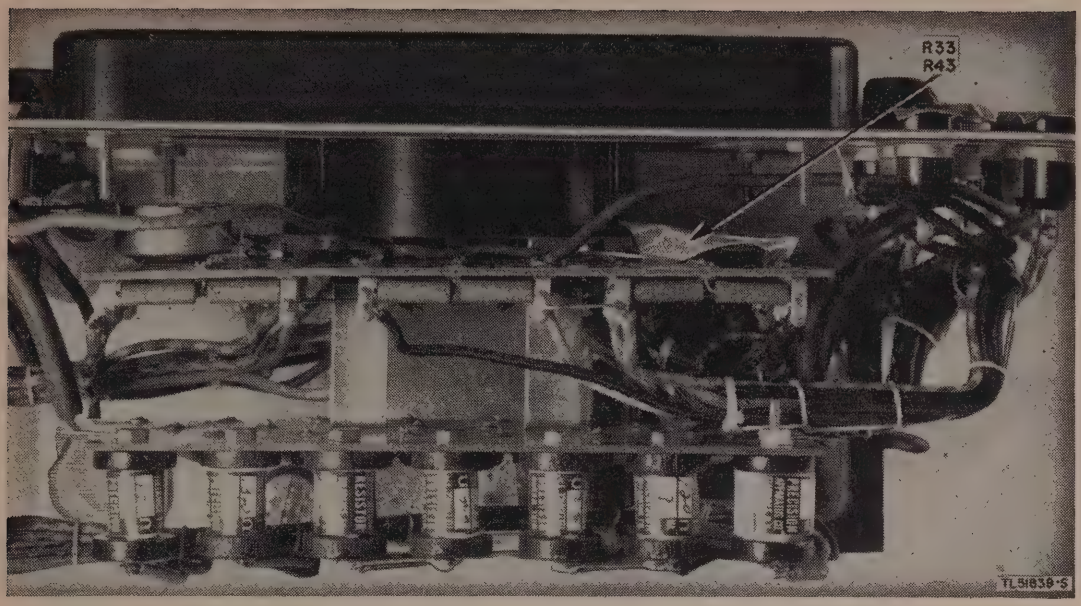


Figure 11. Masking of parts on chassis for moistureproofing and fungiproofing.

(4) Mask the meter screw zero-set adjustment (SJ in fig. 8).

(5) Mask pilot lamp jewel (PL in fig. 8).

(6) Mask all rubber-covered wire. Lacquer is injurious to rubber.

(7) Mask the top of JAN-OD3/VR-150 tube socket (S in fig. 9).

(8) Mask solder connections where a-c line cord was removed (S in fig. 10).

(9) Mask (OHMS ZERO CHECK) power switch (S3 in fig. 10).

(10) Mask CIRCUIT SELECTOR switch (S1 in fig. 10).

(11) Mask master-range selector switch (four sections) (S2 in fig. 10).

(12) Mask rear cover of OHMS ZERO ADJUST and V.T.V.M. ZERO ADJUST controls (R36 and R39 in fig. 9) to keep lacquer mist from penetrating internally.

(13) Mask rubber grommet (G in fig. 12) in rear of cabinet (a-c line cord).

(14) Mask battery spring contact (SC in fig. 10).

(15) Mask the four potentiometers (R28 and R30 in fig. 9 and R33 and R43 in fig. 11) on the rear side of the resistor terminal board directly behind the meter.

Note. Do not disturb position of these potentiometers because they determine the calibration and thus, the accuracy of the equipment.

e. DRYING. Place equipment in an oven or under heat lamps for 4 to 6 hours at a temperature of 140° F.

Note. If wax begins to melt, decrease the temperature and increase the drying time 1 hour for each 10° F drop.

f. VARNISHING. (1) Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, Spec. No. 71-2202 (Stock No. 6G1005.3), or equal). Allow each coat to dry for 15 or 20 minutes at 140° F.

(2) Apply varnish immediately after the equipment is dried. If varnish

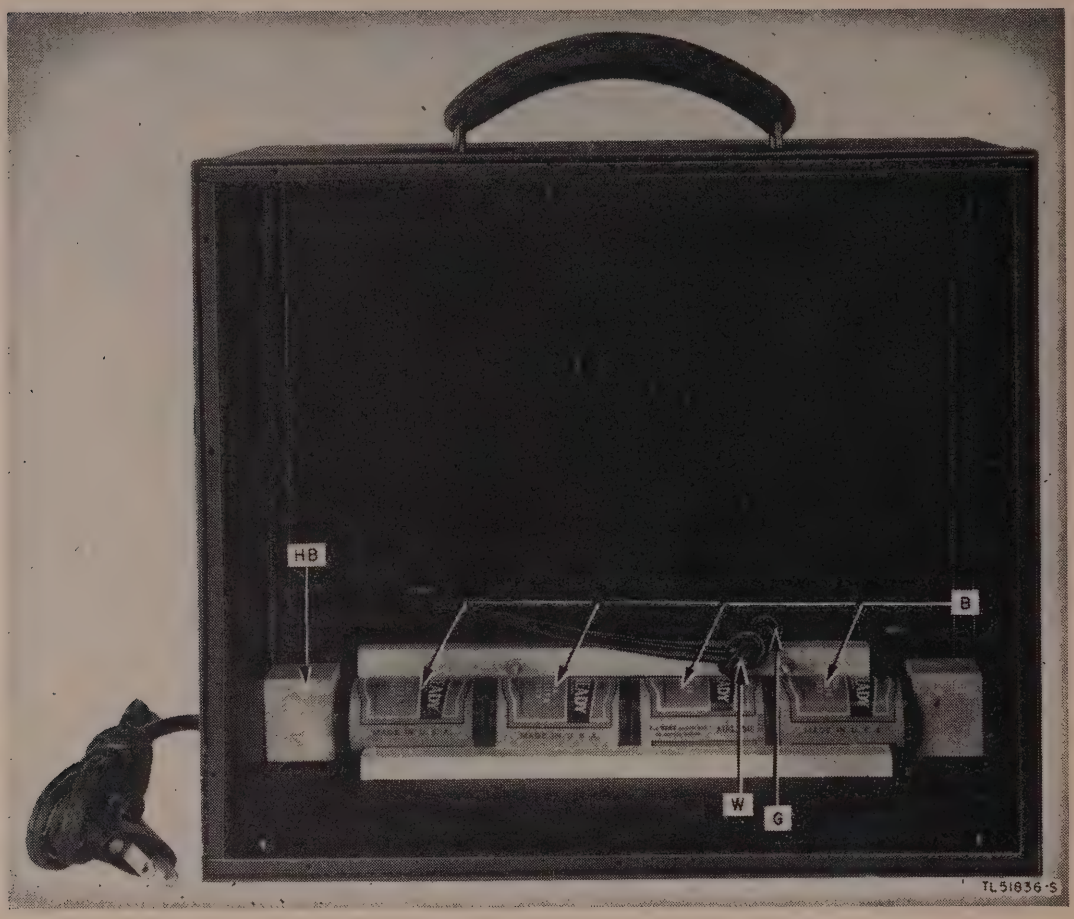


Figure 12. Masking of parts in battery compartment for moistureproofing and fungiproofing.

is not applied immediately, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

(3) Use a brush to varnish components not reached by the spray gun.

g. REASSEMBLY. (1) Remove masking tape; take care not to peel varnish from nearby areas.

(2) Touch up, with varnish, capacitors which were covered by masking tape.

(3) Replace all cables as neatly as possible.

(4) Reassemble the equipment by following the instructions for disassembly in reverse order.

(5) Test the set for operation.

h. MARKING. Mark the letters MFP and the date of treatment in the upper right-hand corner next to the nameplate.

EXAMPLE: MFP—8 Dec 44.

44. Moistureproofing and Fungiproofing after Repairs

If, during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment, apply a brush coat to the affected part. Be sure the break is completely sealed.

PART FOUR

AUXILIARY EQUIPMENT

(NOT USED)

PART FIVE

REPAIR INSTRUCTIONS

Note. Failure or unsatisfactory performance of equipment used by Army Ground Forces will be reported on WD AGO Form 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form 54 (Unsatisfactory Report). If either form is not available, prepare the data according to the sample form reproduced in figure 27.

Section IX. THEORY OF EQUIPMENT

45. Basic Theory

The multi-range tester is a combination test instrument which is used to measure d-c and a-c voltages, resistance, d-c current, decibels, and to make output tests. Although a single meter is used as the indicating device, a wide range of measurements may be made by operating switches on the front panel of the instrument.

a. V.T.V.M. OHMS Circuit. A bridge circuit, one arm of which is the plate-cathode resistance of a triode tube (JAN-6C5GT/G), is used for d-c voltage and resistance measurements. Figures 18 and 19 show simplified schematic diagrams of these two circuits and figure 30 shows a complete schematic diagram of the instrument. Note the similarity of the circuits in figures 18 and 19. The operation of either circuit is accomplished by an unbalance of the bridge circuit.

(1) Meter zero adjustment for resistance measurements is established by an initial bridge circuit unbalance which deflects the meter pointer to the left-zero position on the OHMS scale (Scale A in fig. 4). This position of the pointer nearly coincides with the nonoperating zero setting of the meter (par. 9*d*).

(2) Meter zero adjustment for the d-c voltage measurement circuit, on the other hand, is accomplished through an initial bridge circuit unbalance which deflects the meter pointer to center-scale zero (scale B in fig. 4).

(3) In either type of measurement function, however, operation of the circuit is affected through variations of the plate-cathode resistance of the triode tube. These variations are caused by changes produced on the grid bias voltage of the tube when a measurement is being made.

(*a*) For d-c voltage measurements, the triode tube grid bias voltage change is caused by the application of the external voltage being measured.

(*b*) An internal battery, on the other hand, supplies the triode tube grid bias voltage for resistance measurements. The introduction of the resistance being measured affects the magnitude of this bias voltage.

(4) For voltage measurements, the meter is calibrated to read the magnitude and polarity of the d-c voltage being measured (scale B in fig. 4). The calibrated range is extended through a built-in resistance type voltage-divider network. The resistance in the network (and thus the voltage range obtained) is determined by the position of the master-range selector switch S2.

(5) For resistance tests, the meter is calibrated to read the value of the resistance being measured (scale A in fig. 4). The range of measurements is again extended through the use of another built-in resistance type voltage-divider network. Master-range selector switch S2 selects the various ranges.

(6) The plate voltage for the triode tube in the bridge circuit is obtained from a voltage-regulated rectifier. The regulation reduces instability in the bridge circuit and increases the accuracy of the instrument by correcting for fluctuations in the line voltage (a-c power source).

(7) Additional information for the VTVM measurements circuits is given in paragraphs 50 and 51.

b. AC. V. DB. AND DC. V. MA. CIRCUITS. The meter is used independently of the bridge circuit for all tests except those given above in subparagraph a above. The meter is used in conjunction with resistance networks for the d-c current and d-c voltage (1,000 ohms per volt) measurements. For the a-c applications, a resistance network and a copper-oxide rectifier are used with the meter. Details for these circuits are given in paragraphs 46 through 49.

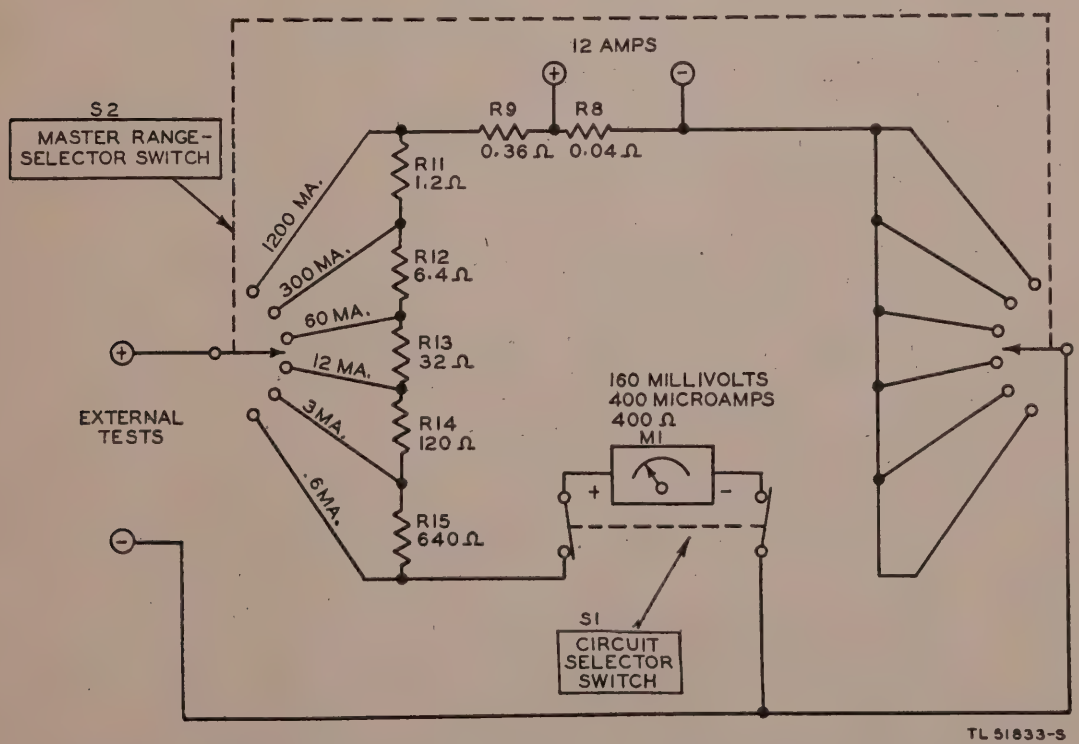


Figure 13. Simplified schematic diagram of d-c current measurements circuit.

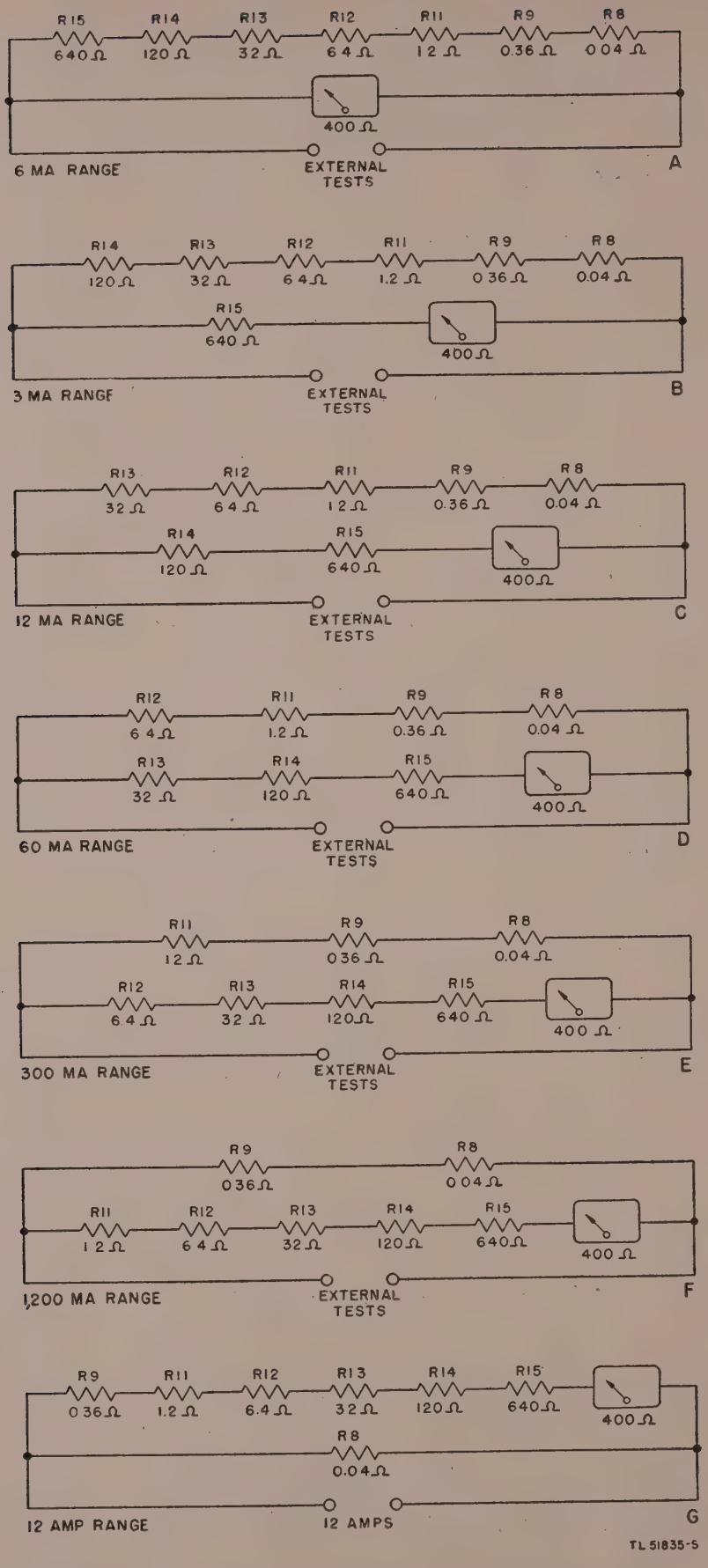


Figure 14. Simple circuits of seven d-c current ranges.

46. D-c Current Measurements Circuit

a. General. The 400-microampere meter (M1) is used in conjunction with suitable resistors for d-c current measurements. Figure 13 shows the simplified schematic diagram. The master-range selector switch S2 selects any one of six current ranges (0.6 MA, 0-3 MA, 0-12 MA, 0-60 MA, 0-300 MA, and 0-1200 MA). The CIRCUIT SELECTOR switch, when thrown to the DC. V. MA. position, automatically connects the current measurements circuits. The test leads are connected to the terminals marked EXTERNAL TESTS. Two additional terminals marked 12 AMPS are provided for the measurement of higher currents. The functioning of parts is given in subparagraphs *b* through *e* below.

b. .6 MA. Range. When switch S2 is thrown to the .6 MA. position (fig. 14A), the meter coil is connected in parallel with series resistors R15, R14, R13, R12, R11, R9, and R8. The value of these resistors in series is 640 + 120 + 32 + 6.4 + 1.2 + 0.36 + 0.04, or 800 ohms. The resistance of the meter coil is 400 ohms. Therefore, when a current is applied to the EXTERNAL TESTS terminals, two-thirds of this current will flow through the meter coil and one-third through the series resistors. If, for example, a current of 0.6 ma (600 microamperes) is applied, two-thirds of this current, or 400 microamperes, will flow through the meter coil and cause full-scale deflection of the pointer. The other 200 microamperes will flow through the series resistors.

c. 3 MA. Range. When switch S2 is thrown to the 3 MA. position (fig. 14B), the meter is connected in series with resistor R15 and this combination is placed in parallel with series resistors R14, R13, R12, R11, R9, and R8. Therefore, one leg of the circuit contains 400 + 640, or 1040 ohms. The other leg contains 120 + 32 + 6.4 + 1.2 + 0.36 + 0.04, or 160 ohms. The combined value of 1040 ohms in parallel with 160 ohms is 138.66 ohms, which is present across the EXTERNAL TESTS terminals. When a current is applied to these terminals, part will flow through one leg of the circuit and part through the other leg. For example, if a current of 2 ma (0.002 amps) is applied, the voltage drop across the circuit will be, by Ohm's law, 0.002 multiplied by 138.66, or 0.277 volts. Therefore, the current through resistor R15 and the meter will be 0.277 divided by 1040, or 0.000266 amperes (266 microamperes). This current will cause the pointer to indicate two-thirds of full scale. The reading will be 2 ma. The balance of the applied current will flow through the series resistors.

d. Other MA Ranges. Figures 14C through F show the circuits which are connected when S2 is rotated consecutively to higher ranges. Note that the resistance in series with the meter becomes greater and the shunt resistance becomes smaller as the switch is rotated to the higher current ranges. As a result of this shift in resistance, less applied current

flows through the meter coil in comparison to the current which flows through the shunt resistors. Consequently, larger currents are necessary to cause full-scale deflection of the pointer on the meter and larger currents may be applied and measured. The method of determining the actual current flow through each leg for any given value of applied current may be determined, if desired, by using the same type of calculation as given in subparagraph *c* above.

e. 12 AMP. RANGE. Figure 14G shows the circuit used when high values of current are to be measured. The current is applied to the 12 AMP. terminals instead of to the EXTERNAL TESTS terminals. Resistor R8 (0.04 ohms) is connected in parallel with the input terminals and all other resistors in the network are connected in series with the meter coil. Consequently, only a small proportion of the applied current is allowed to pass through the meter coil.

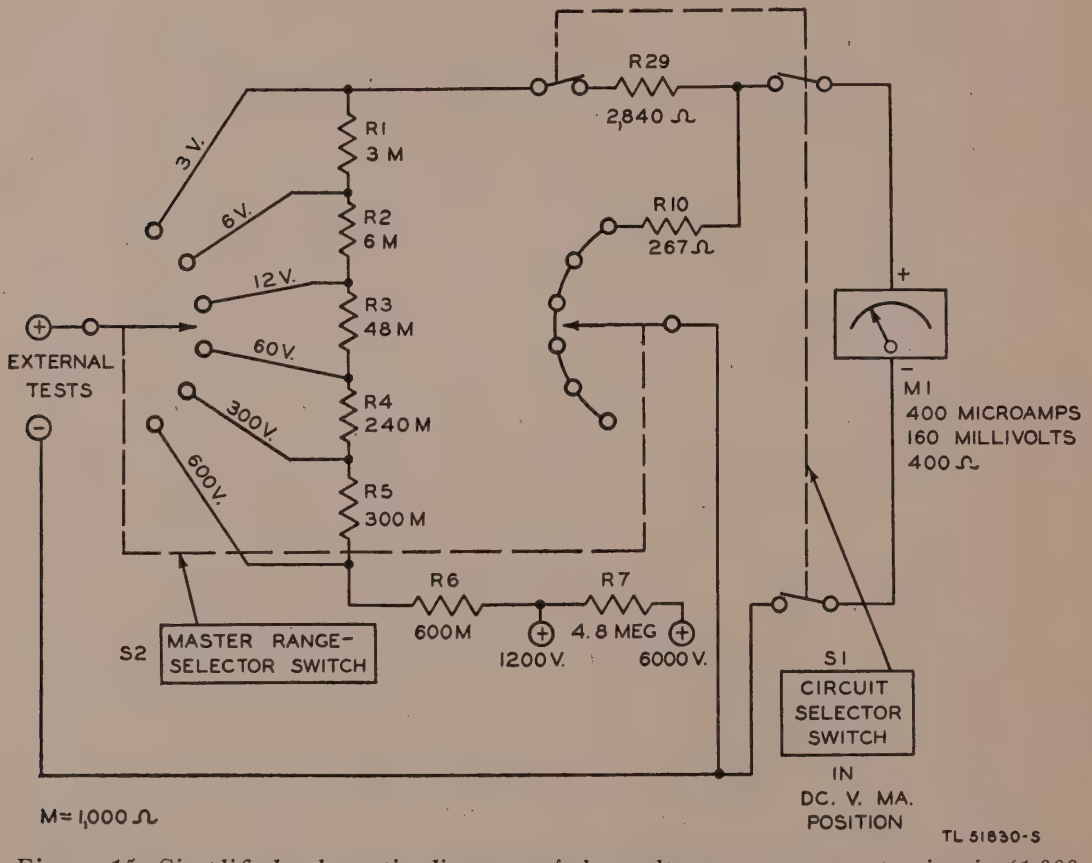


Figure 15. Simplified schematic diagram of d-c voltage measurements circuit (1,000 ohms per volt)

47. D-c Voltage Measurements Circuit (1,000 ohms per volt)

a. GENERAL. Meter M1, with a different set of resistors is used to measure d-c voltages between 0 and 6,000 volts without having to connect the equipment to an a-c power source. Figure 15 shows a simplified schematic diagram. The input resistance of the circuit is 1,000 ohms per volt (3,000 ohms on the 3V. range, 6,000 ohms on the 6V. range, etc.).

When the test leads are connected to the EXTERNAL TESTS terminals, any one of six ranges may be selected by rotation of the master-range selector switch S2. These ranges are 0 to 3V., 0 to 6V., 0 to 12V., 0 to 60V., 0 to 300V., and 0 to 600V. Two additional terminals are provided for the measurement of higher voltages (0-1200V and 6000V ranges). The CIRCUIT SELECTOR (switch S1) when rotated to the DC. V. MA. position, automatically connects the proper circuits. The functioning of parts is given in subparagraphs *b* through *e* below.

b. METER SHUNT. Resistor R10 (267 ohms) is shunted across the 400-ohm meter coil for all ranges (resistance across combination = 160 ohms). This shunt resistance gives the meter a full-scale sensitivity of 1 ma, or, in other words, a 1 ma-current, which if applied in series with the combination, will cause a full-scale deflection of the meter.

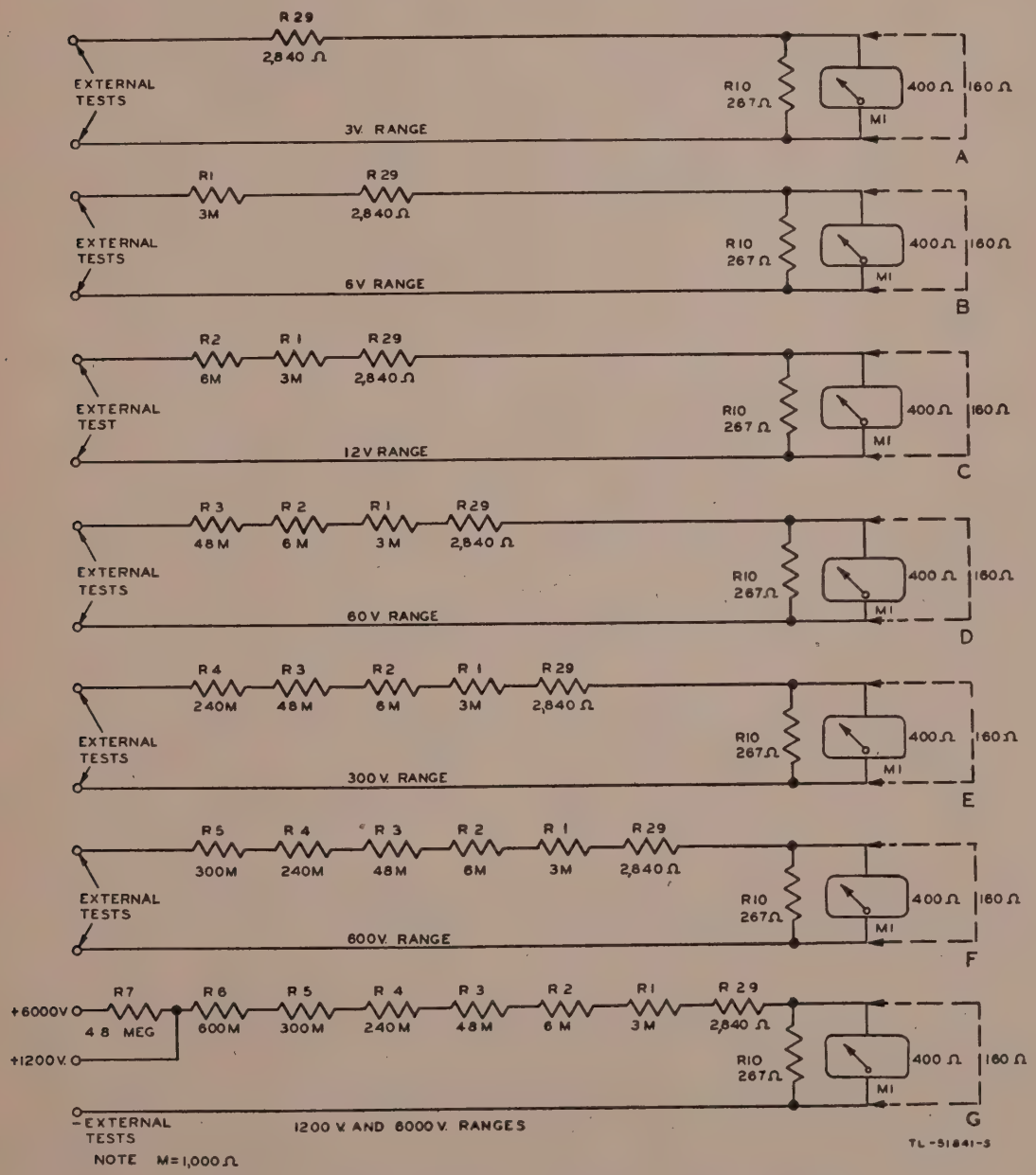


Figure 16. Simple circuits of eight d-c voltage ranges.

c. 3V. RANGE. Figure 16A shows a simple schematic diagram of the circuit for the 3V. range. Resistor R29 (2840 ohms) is placed in series with the meter and its shunt resistor R10. The total resistance presented at the EXTERNAL TESTS terminals is 2840 + 160, or 3,000 ohms. When a voltage of 3 volts is applied at the terminals, a current of 1 ma flows through the circuit ($I = \frac{E}{R} = \frac{3}{3000} = .001$ amp = 1 ma) and causes a full-scale deflection of the meter. See subparagraph *b* above.

d. 6V. RANGE. Figure 16B shows the circuit for the 6V. range. This circuit is identical to figure 16A except for the presence of the series resistor R1 (3,000 ohms). The total resistance presented to the input terminals is 6,000 ohms, and as a result, a 6-volt input is necessary for a full-scale deflection of the meter.

e. OTHER RANGES. Figures 16C through G are simplified diagrams of the circuits employed for each of the other d-c voltage ranges. Note that as the voltage range becomes higher, the only change in the circuit is the inclusion of greater series resistance. The resistor values are so selected that exactly 1 ma of current will flow through the meter when the maximum voltage for each range is applied to the input terminals. The operating data for each range may be computed, if desired, by using the procedure given in subparagraph *c* above and substituting the proper resistor values and voltage inputs for the various ranges.

48. A-c Voltage Measurements

The circuit for the measurement of a-c voltage makes use of a copper-oxide rectifier, suitable resistors, and meter M1. Figure 17 shows a simplified schematic diagram. Because of the capacity between discs in this type of rectifier, the impedance rises with frequency and places an upper limit on a-c voltage measurements at approximately 8,000 cycles per second. Large errors are introduced at higher frequencies. When CIRCUIT SELECTOR switch S1 is rotated to the AC. V. -DB. position, the circuits are connected as shown in figure 17. Note the similarity between the a-c and the d-c voltage measurements circuits (figs. 15 and 17). The functioning of parts is the same in both circuits except for the following:

a. The copper-oxide rectifier (X1) is used for a-c measurements and converts the alternating current to direct current, before application to meter M1.

b. Potentiometer R28, a 3,000-ohm variable resistance, replaces the 2840-ohm fixed resistor R29.

c. Potentiometer R30, a 12,000-ohm variable resistance, replaces resistor R10, a 267-ohm fixed resistance.

d. The inherent resistance of the copper-oxide rectifier acts as a shunt across the meter and also as a series resistance between R28 and the

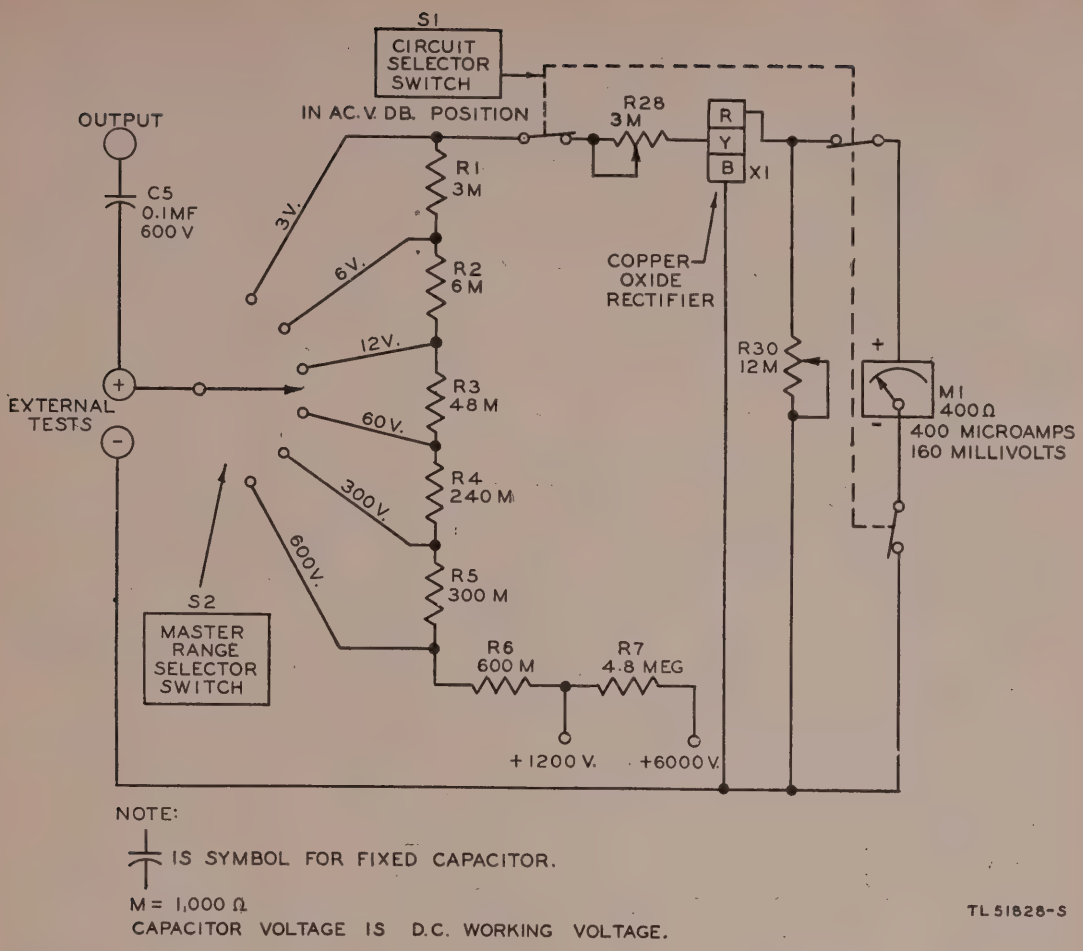


Figure 17. Simplified schematic diagram of a-c voltage measurements circuit.

meter. For this reason, the values of R29 and R10 in the d-c voltage circuit are not the same as the values of R28 and R30 in the a-c voltage circuit. The resultant resistance of the combinations, however, is approximately the same for either circuit and the resistance presented at the input terminals for any given range is approximately the same for d-c or a-c measurements.

e. Potentiometers R28 and R30 are calibration controls. Once calibration is performed (sec. XIII), further adjustments of these controls are usually unnecessary unless a part is replaced.

49. Decibel Measurements and Output Tests

The circuit used for a-c measurements is also used for decibel measurements and output tests. There is a special meter scale (Scale E in fig. 4) employed for the decibel measurements. This scale is calibrated in decibels and, when used with the correction chart in paragraph 15, makes possible db readings from —26 db to +70 db. For output tests, a special pin jack is provided to which one of the test leads is connected. This jack places a capacitor C5 in series with the input and prevents the d-c voltage from reaching the measurements circuit.

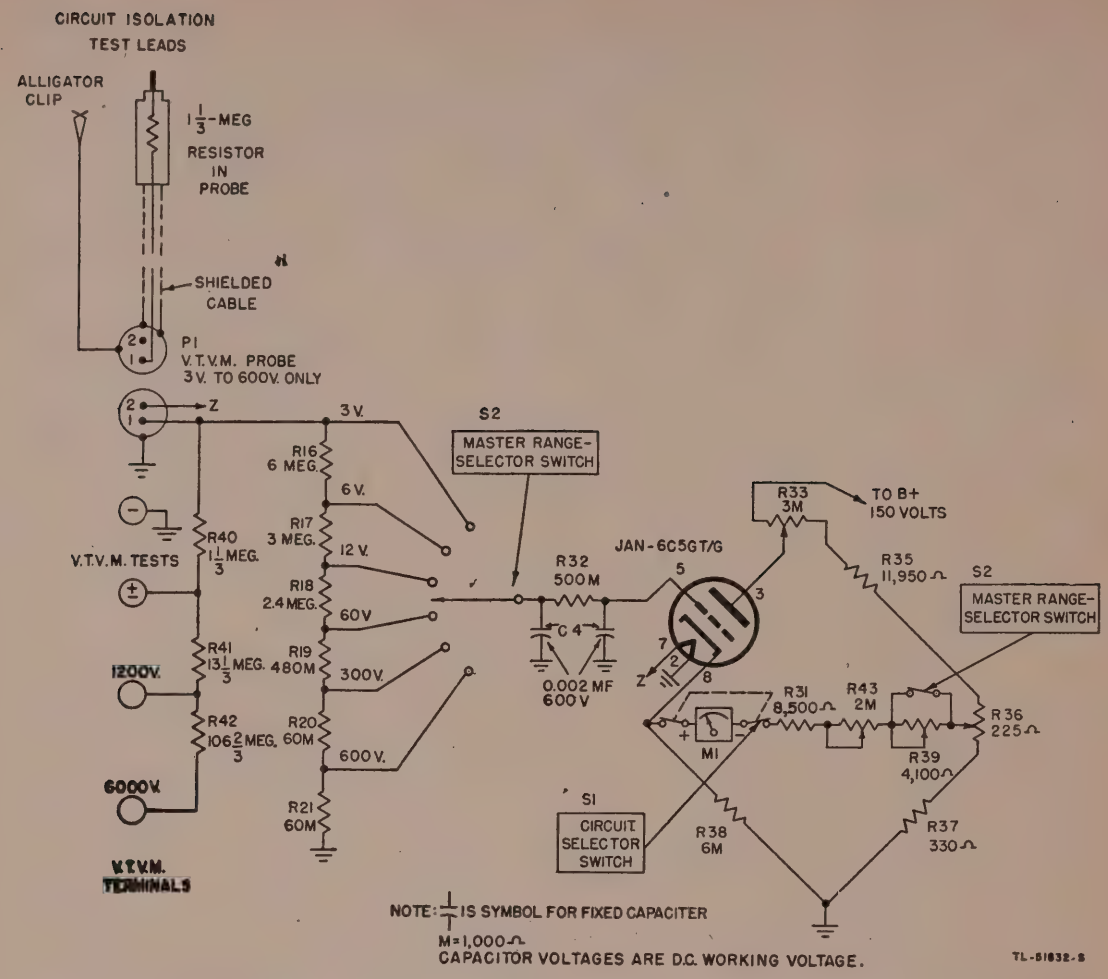


Figure 18. Simplified schematic diagram of d-c voltage measurements circuit (VTVM).

50. D-c Voltage Measurements Circuit (VTVM)

a. General. The d-c vacuum tube voltmeter utilizes a bridge circuit. See figure 18 for simplified schematic diagram. The triode tube JAN-6C5GT/G serves as one leg of the bridge.

b. Bridge Circuit. Stability of operation without greatly reduced sensitivity is made possible by the use of a large value of cathode resistance in this bridge circuit. The circuit operates as follows:

(1) With no voltage applied at the input terminals and the master-range selector switch in any one of the voltage positions, the grid of the triode tube is connected through resistance to ground. This places the grid of the tube at ground potential (grid current flow is negligible).

(2) If the meter were temporarily disconnected from the circuit and 150 volts were applied between potentiometer R33 and ground, there would be two possible paths of current flow in the bridge circuit. One path would be through potentiometer R33, resistor R35, potentiometer R36, and resistor R37. The other path would be through part of potentiometer R33, the plate-cathode resistance of the tube, and through resistor R38.

(3) A balanced-bridge condition exists when the voltage at the cathode of the tube is exactly equal to the voltage at the movable arm of potentiometer R36. With the bridge so balanced and with the meter connected, the pointer of the meter will not deflect from its original nonoperating position. If, however, the voltage at the cathode is not exactly equal to the voltage at the movable arm of potentiometer R36, the bridge circuit is unbalanced and, because of the difference in potential, a current flows through the meter, resistor R31, and potentiometer R43. The amount of this current flow is proportional to the degree of unbalance in the bridge circuit.

c. Operation of Bridge. (1) When the instrument has been properly calibrated and adjusted, and d-c voltage is not being measured, the meter pointer rests at center-scale on the meter. Center scale is the zero voltage position for d-c VTVM measurements. If, as explained in subparagraph *b* above, the bridge were balanced, the meter pointer would rest at its nonoperating position (zero on the D.C. or A.C. scale). Thus, the bridge is purposely unbalanced by adjustment of potentiometer R36, the V.T.V.M. ZERO ADJUST control, to cause a current flow through the meter which deflects the pointer to center scale.

(2) When a positive voltage is applied to the grid of the tube, the plate-cathode resistance decreases, the current flow through the tube and resistor R38 increases, and the cathode of the tube becomes more positive with respect to ground. The voltage at the movable arm of potentiometer R36 remains practically constant. Thus, the unbalance in the bridge becomes greater and the meter pointer deflects to the right of center scale.

(3) On the other hand, when a negative voltage is applied to the grid of the tube, the plate-cathode resistance increases, the current flow through the tube and resistor R38 decreases, and the cathode of the tube becomes more negative with respect to ground. Thus, the unbalance in the bridge is smaller and the meter pointer deflects to the left of center scale.

d. Voltage-Divider Resistor Network. If the voltage-divider resistor network were omitted from this circuit and a single resistor connected between the control grid of the bridge tube and ground, only voltages between 0 and approximately 2.7 volts could be applied to the grid of the tube. This is true since a voltage of 2.7 volts on the grid is made to cause full-scale deflection of the meter when the calibration potentiometers R33 and R43 are properly adjusted. The bridge is so designed that meter readings are linear when voltages within this range are applied to the grid. The purpose of the voltage-divider network, therefore, is to reduce input voltages applied at the V.T.V.M. TESTS, 1200V., and 6000V. terminals to a proportionate value between 0 and 2.7 volts before application to the grid of the tube. A more detailed explanation follows.

(1) The total resistance between the V.T.V.M. TESTS terminals is 13.33 megs. The total resistance between the 1200V. terminal and the

GND. terminal is 26.66 megs; and the total resistance between 6000V. terminal and the GND. terminal is 133.33 megs.

(2) When 3 volts are applied between the V.T.V.M. TESTS terminals, a current of 0.000,000,225 amperes (0.225 microamperes (μa)) flows through resistors R40, R16, R17, R18, R19, R20, and R21. With the master-range selector switch S2 set at the 3V position, the voltage appearing at the grid of the bridge tube will be equal to this current multiplied by the resistance between the control grid and ground, or 2.7 volts (0.225 μa times 12 megs). This voltage, as explained above, will cause a full-scale reading of the meter. One VTVM scale on the meter reads from 0 to 3 volts.

Note. Because no grid current flows in the triode tube there is no voltage drop across resistor R32.

(3) When 6 volts are applied between the V.T.V.M. TESTS terminals, a current of 0.000,000,450 amperes (0.450 μa) flows through the resistors. When switch S2 is set at 6V. position, the voltage appearing at the grid will again be equal to this current multiplied by the resistance between the grid of the tube and ground, or 2.7 volts. This again will cause full-scale deflection of the meter, although a different meter scale (0 to 6 volts) is used.

(4) The same procedure may be used for calculating different input voltages and different settings of the range switch. In each case, however, a full-scale deflection of the meter will be caused by the application of 2.7 volts to the grid of the triode tube. For intermediate values of voltages, of course, a partial deflection of the pointer on the meter will result.

(5) When the 1200V. or 6000V. terminals are used, the resistor values in the network change and a greater voltage drop occurs before the lowered voltage is applied in the grid of the tube. When voltages in excess of 600 volts are to be measured, these terminals must be used instead of the V.T.V.M. TEST terminals.

e. Resistance-capacitance Filter. The two capacitors C4 and the resistor R32 in the grid circuit of the tube are used to safeguard the meter.

(1) In the event an a-c voltage is accidentally applied to the d-c voltage input terminals, the capacitors will bypass a large portion of this voltage to ground and prevent its application to the grid of the tube. If the capacitors were not present, the a-c voltage would reach the grid, cause the bridge circuit to respond to the alternations, and result in an a-c current through the meter.

(2) In the event a high value of d-c voltage is applied at the input terminals when switch S2 is set at too low a voltage range, a high value of positive voltage will instantaneously appear at the grid of the tube. This voltage will cause the grid to become positive to such an extent that grid current will flow between the grid and cathode of the tube,

through resistor R32, and the resistor-divider network to ground. The grid current flow through resistor R32 will cause a voltage drop across this resistor and thus will reduce the amount of positive voltage applied at the grid of the tube. This reduction in grid voltage protects the meter to a great extent, but is not a complete precaution because the initial application of the high voltage at the grid affects the meter for an instant before grid current flows.

f. Degeneration in Bridge Circuit. The presence of a large value of cathode resistance (6,000-ohm resistor R38) results in a large amount of degeneration in the bridge circuit. This degeneration increases the stability of the bridge and partially corrects for differences in operating characteristics of various tubes. In addition, it permits a more linear change in plate current with respect to a change in the d-c voltage being measured, and allows a linear d-c scale to be used on the meter. The operation is as follows:

(1) When a positive voltage is applied at the grid of the triode, as previously explained, the plate-cathode resistance of the tube decreases and a greater current flows through the tube and through resistor R38. This increase of current flow causes the cathode of the tube to become more positive in respect to ground and causes a deflection of the meter's pointer.

(2) At the same time, however, a more positive cathode increases the grid bias voltage on the tube in a negative direction (positive cathode has the same effect as negative grid in controlling bias). This again tends to increase the plate-cathode resistance of the tube at the same time that the positive voltage applied at the grid tends to decrease the plate-cathode resistance. Thus we have one voltage bucking the other. The change in bias voltage as the result of degeneration, however, is not nearly as great as the change in bias voltage resulting from the application of the voltage on the grid.

g. Calibrating Controls. Potentiometers R33 and R43 are the calibrating controls for the VTVM circuits. Calibration procedures are given in section XIII. In general, these controls are so adjusted that the meter will give the correct value of an applied voltage (or resistance).

(1) Potentiometer R43 is connected in series with the meter. Thus, any change in its setting will affect the sensitivity of the meter in respect to the difference of potential which may exist between the movable arm of potentiometer R36 and the cathode of the tube.

(2) During calibration, these controls are not only adjusted for correct meter readings, but they are also adjusted to obtain zero (and infinity) readings before measurements are made. This is done by operating the front panel controls R36 and R39 which are marked V.T.V.M. ZERO ADJUST and OHMS ZERO ADJUST.

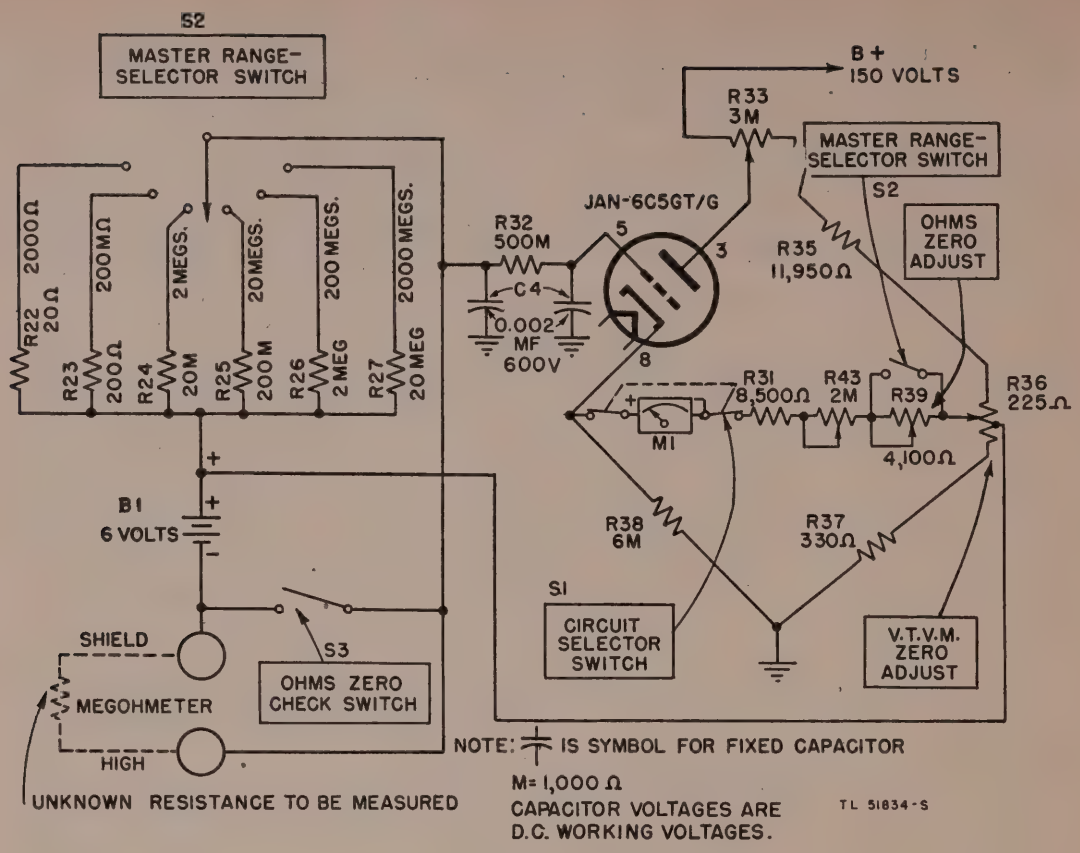


Figure 19. Simplified schematic diagram of resistance measurements circuit.

51. Resistance Measurements Circuit

a. General. The VTVM circuit which is used for d-c voltage measurements, as explained in paragraph 50, is also used (with modification) in the resistance measurements circuit. (See fig. 19.) The resistance measurements circuit has its own resistor voltage-divider network which includes a 6-volt dry-cell battery. The MEGOHMMETER pin jack terminals marked HIGH and SHIELD are used. The operation of the circuit is basically the same as for d-c voltage measurements. A voltage applied at the grid of the bridge tube causes a deflection of the pointer on the meter. However, the method of obtaining the applied grid voltage is different. Instead of using an external d-c voltage source, the voltage which is applied to the grid of the tube in the resistance measurements circuit is obtained from the dry-cell battery. The amount of actual voltage applied at the grid depends on the value of the resistance being measured. In order to insure linear operation for the bridge tube, a potential of approximately 4 volts is tapped off potentiometer R36 and connected into the resistance voltage-divider network.

b. Voltage-divider Network. Figure 20 shows a simple schematic diagram of the voltage-divider network when the master-range selector switch is in the 2,000 ohm position.

(1) In figure 20, potentiometer R33, resistor R35, potentiometer R36, and resistor R37 are connected between the positive 150-volt output of the

regulated rectifier and ground. Because of the resistance values in this combination, voltage drops occur across the resistances in such a manner that point A in figure 20 is placed at approximately 4. volts in respect to ground. As a result of this connection, the positive terminal on the 6-volt dry-cell battery is at a potential of approximately +4 volts above ground and the negative terminal of the battery is at a potential of —2 volts below ground.

(2) When the OHMS ZERO CHECK switch S3 is closed, the SHIELD and HIGH terminals are shorted and a closed circuit is formed which consists of the battery, resistor R22, and the closed contacts of switch S3. In this circuit, the entire voltage drop of 6 volts appears across R22 (the battery is the supply source). Simultaneously, a potential of —2 volts is applied to the grid of the bridge tube and causes a deflection of the meter pointer.

(3) When the OHMS ZERO CHECK switch S3 is open and no resistance is connected between the HIGH and SHIELD terminals, the closed circuit mentioned in (2) above does not exist. In this case, a potential of +4 volts is applied to the grid of the bridge tube. No voltage drop occurs across resistor R22 because there is no current flow in the open circuit.

Note. When the master-range selector switch is at the 2,000 ohms position and the OHMS ZERO CHECK switch is held closed, a high current flows in the circuit. This current will run down the batteries quickly if the switch is held in the ZERO CHECK position for any length of time. For this reason, use the OHMS CHECK position only as long as necessary to make a zero adjustment.

(4) When a resistance is to be measured, it is inserted between the SHIELD and HIGH terminals. Assume that a 60-ohm resistor is inserted between these terminals. Again a closed circuit will be formed consisting of the battery, resistor R22, and the 60-ohm resistance being measured. The voltage in the circuit will be 6 volts (the battery voltage) and the resistance in the circuit will be 80 ohms (the sum of resistor R22 and the resistance being measured). By Ohm's Law, the current around the circuit will be equal to the voltage divided by the resistance, or 0.075 amperes. The voltage drop across resistor R22 will be equal to the current multiplied by the resistance of 20 ohms, or 1.5 volts. Thus, +2.5 volts will be applied to the grid of the bridge tube.

(5) As the value of the resistance being measured is changed, a lower or greater current will flow around the closed circuit and in this way cause a more positive or a more negative potential to be applied to the grid of the bridge tube.

(6) Figure 20 and the above subparagraphs have been based on the master-range selector switch S2 being set at 2,000-ohm position. The only change which would occur if another resistance range were used would be the substitution of another resistor in place of R22. For example, on the

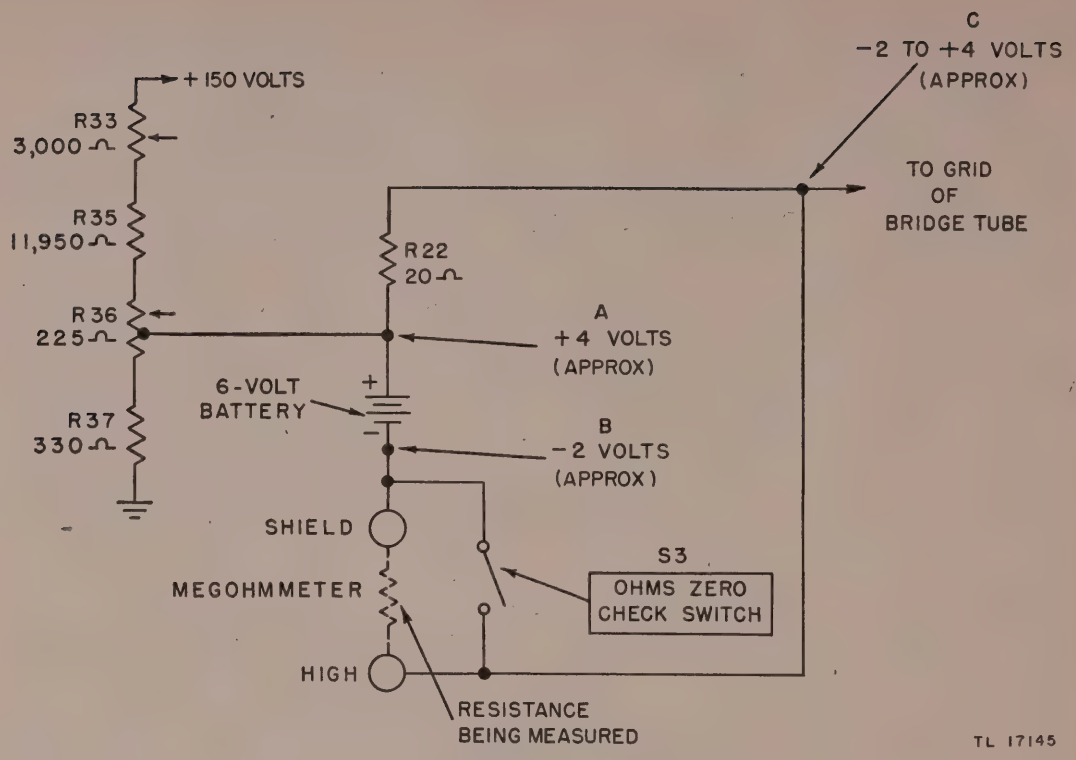


Figure 20. Simple circuit of voltage-divider network for resistance measurements circuit.

200 M-ohm range, a 200-ohm resistor would replace the 20-ohm resistor; on the 2-MEGS range, a 20,000 resistance would replace the 20-ohm resistance, etc. The functioning of the circuit is the same regardless of which range is in use. However, the substitution of the higher resistance in place of the 20-ohm resistance makes possible the measurement of higher resistance values.

c. Meter Circuit. The meter circuit for resistance measurements is almost the same as that used for d-c voltage measurements. One change may be noted. (See figs. 18 and 19.) Potentiometer R39, the OHMS ZERO ADJUST control is placed in series with potentiometer R43, resistor R31, and the meter when making resistance measurements. Potentiometer R39 is automatically connected into the circuit when the master-range selector switch is rotated from the voltage to the resistance ranges. Resistor R39 is used in combination with potentiometer R36 (the V.T.V.M. ZERO ADJUST control) when adjusting the meter pointer prior to making measurements. Primarily, the V.T.V.M. ZERO ADJUST control is used for positioning the pointer at the zero mark on the OHMS scale when no resistance is being measured. The OHMS ZERO ADJUST control, on the other hand, is used for properly positioning the pointer of the meter at the infinity mark on the OHMS scale when the SHIELD and HIGH terminals are shorted (OHMS ZERO CHECK switch in OHMS CHECK position).

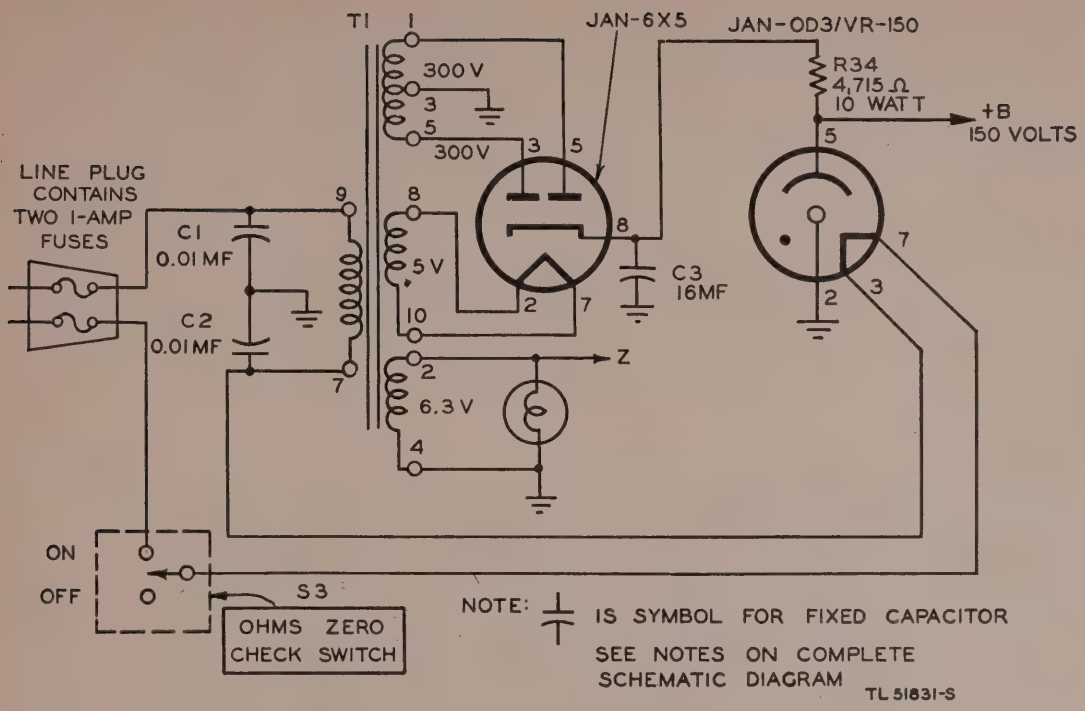


Figure 21. Simplified schematic diagram of regulated rectifier.

52. Regulated Rectifier (figs. 21 and 30)

Rectifier Tube JAN-6X5 is used as a full-wave rectifier in the power supply which furnishes plate and filament voltage for the bridge tube. The high voltage output is held constant at 150 volts through operation of gas voltage regulator Tube JAN-OD3/VR-150.

a. The line cord plug is fitted with two fuses (fig. 6) which protect the components in case an overload condition develops within the equipment.

b. The OHMS ZERO CHECK switch has three positions:

(1) In its OFF position, a-c power is removed from the circuits in the equipment.

(2) In its ON and OHMS CHECK positions, the a-c power is applied to the power transformer.

c. The gas regulator tube contains an internal connection between pins No. 3 and 7. These pins are placed in series wtih one leg of the a-c power input to transformer T1. As a result, a-c power may be removed from the circuits, if desired, by simply removing this tube from its socket.

d. Capacitors C1 and C2 serve as line filters.

e. Transformer T1 has one primary and three secondary windings, one of which is center tapped. This center-tapped winding supplies the high voltage to the rectifier tube. The other two secondary windings supply filament voltage for the rectifier and bridge tubes.

f. The use of the gas voltage regulator tube and the low current drain on the rectifier permits the use of a simple filtering system. Capacitor C3 removes much of the ripple from the rectifier output. Any a-c component

not eliminated by the capacitor is smoothed out through normal action of the gas voltage regulator tube and its series resistor R34.

g. The filament voltage for the rectifier tube is 5 volts instead of the usual 6.3 volts. This lower filament voltage causes the rectifier tube to warm up slowly when the power switch is turned on. As a result, the output voltage of the rectifier is held at a low value until normal operating conditions for the bridge circuit are reached. In this way, the meter pointer does not fly off-scale violently when the power switch is turned on, because the meter is protected from overload while the tubes are heating.

Section X. TROUBLE-SHOOTING PROCEDURES

53. Introduction

No matter how well equipment is designed and manufactured, faults are bound to occur in service. When such faults do occur, the repairmen must locate and correct them as rapidly as possible. This section contains information designed to aid those engaged in the important duty of trouble shooting. (Remember, however, that preventive maintenance will minimize the necessity of trouble shooting.)

a. Trouble-shooting Data. Take advantage of the material supplied in this manual to help locate faults quickly. Consult the following trouble-shooting data when necessary.

(1) *Complete schematic diagram.* This diagram (fig. 30) includes all parts and shows all the connections of the equipment.

(2) *Simplified and partial schematics.* These diagrams are particularly useful in trouble shooting, because they enable the electrical functioning of the circuits to be followed more clearly than on the regular schematics. See diagrams in section IX.

(3) *Voltage and resistance data at all socket connections.* See section XI.

(4) *Illustrations of components.* Front, top, and bottom views aid in locating and identifying parts.

(5) *Pin connections.* Pin connections on sockets, plugs, and on the power transformers are numbered or lettered on the various diagrams. Seen from the bottom, pin connections are numbered in a clockwise direction around the sockets. On octal sockets the first pin clockwise from the keyway is pin No. 1. Pin numbers appear on both the schematic diagrams and the wiring diagrams, so that any tube element can be readily located.

b. Trouble-shooting Steps. The first step in servicing a defective radio set is to sectionalize the fault. *Sectionalization* means tracing the fault to the circuit responsible for the abnormal operation. The second step is to localize the fault. *Localization* means tracing the fault to the defective part responsible for the abnormal condition.

54. Test Equipment Required

The following equipment is needed for testing equipment:

a. A multi-range voltohmmeter, such as Test Unit I-176, Voltohmmeter 1-166, or similar types will be satisfactory for most of the trouble shooting involved.

b. A source of voltage, both alternating and direct current.

c. 1 resistor (5,000 ohms).

d. 1 battery, 1.5 volts (BA-23, BA-30, or BA-1).

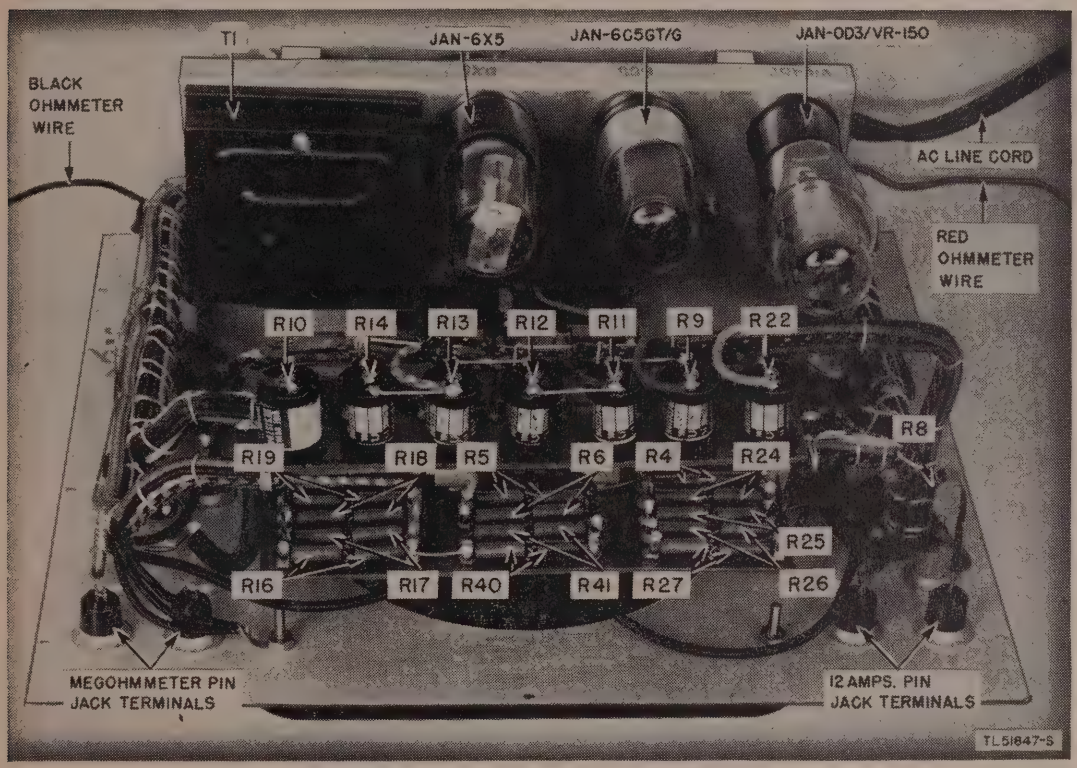


Figure 22. VTVM, top inside view.

55. Sectionalization

Note. Read paragraphs 55 and 56 before starting trouble-shooting operations.

The sectionalization of trouble in the multi-range tester is performed by using the following procedures:

a. Starting Procedure. Perform the steps of the starting procedure explained in paragraph 9. If an abnormal result is obtained when the action in any step is performed, see paragraph 58, starting procedure analysis. However, many troubles cannot be sectionalized by the use of the starting procedure because the instrument is designed for multiple tests and the starting procedure covers only the VTVM circuits of the equipment.

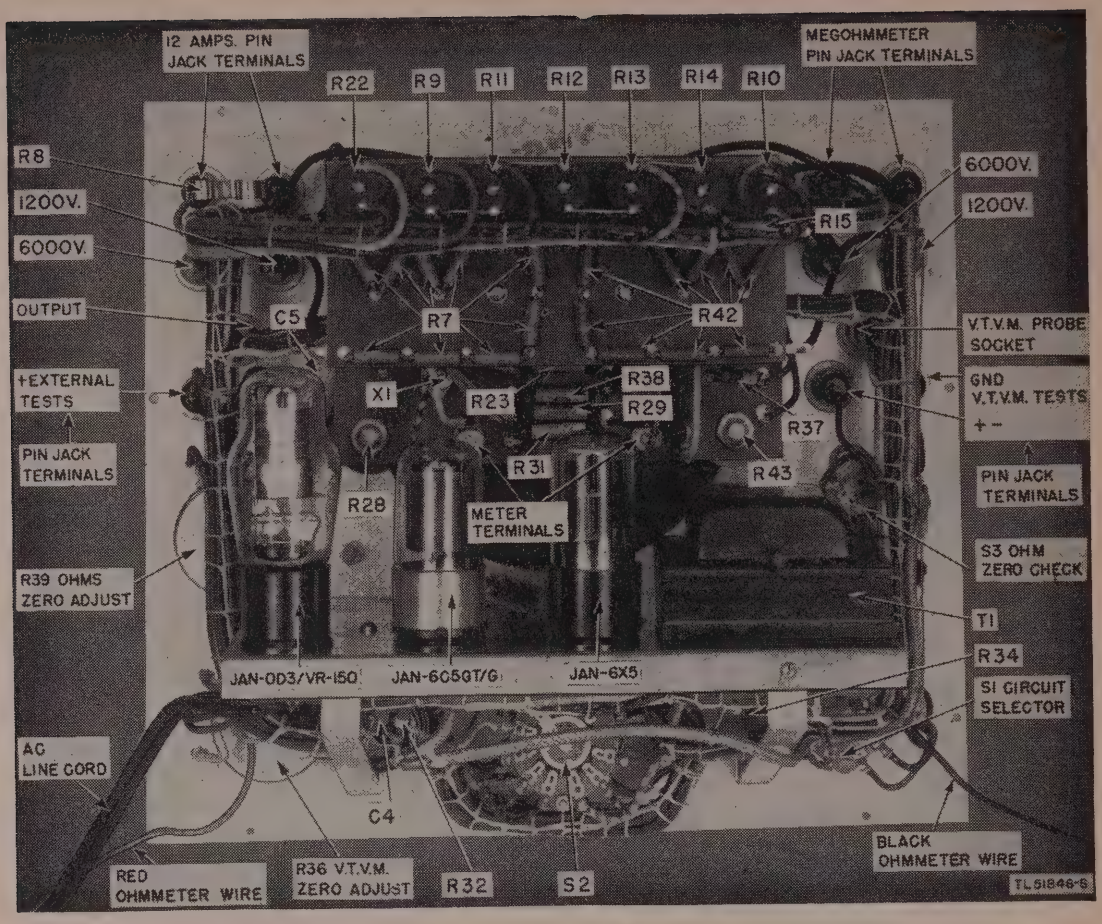


Figure 23. VTVM, rear inside view.

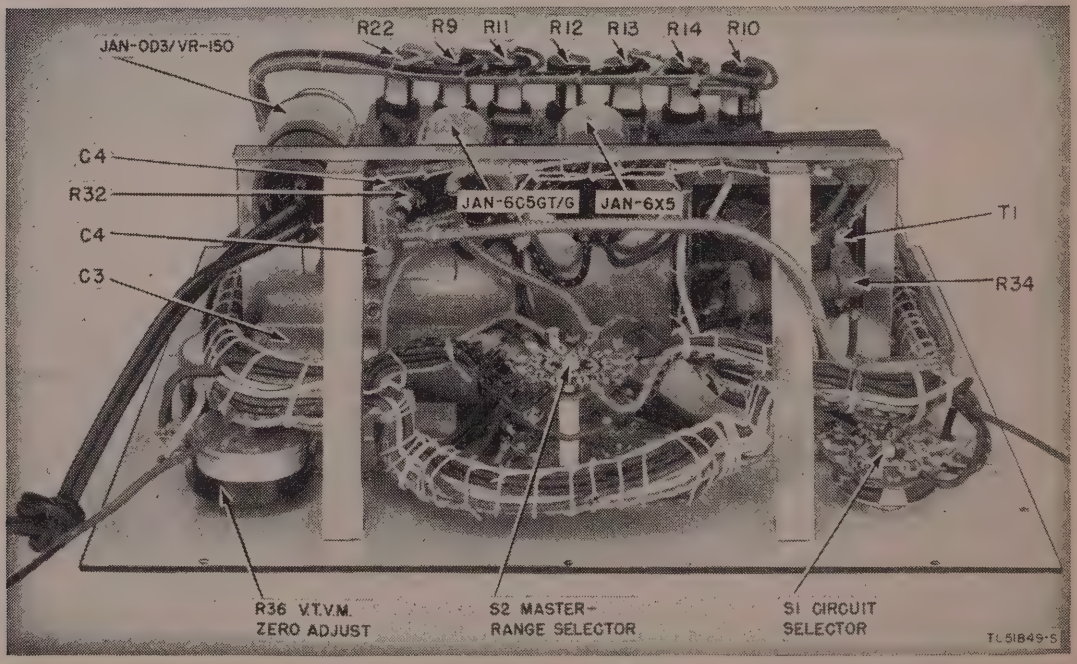


Figure 24. VTVM, bottom of chassis.

b. Operating Procedure. When the equipment is in operation and an abnormal condition is observed, the trouble can be sectionalized to a given circuit as follows:

(1) If it is not possible to obtain a deflection of the meter pointer or if the readings are inaccurate on all measurements circuits, the meter is probably defective. If this is the case, see paragraph 57 for the instructions on testing the meter.

(2) If the meter itself is not defective and normal readings are not obtained on the d-c current measurements circuit, make the resistance tests given in paragraph 60*b*. Figure 13 shows a simplified schematic diagram of this circuit.

(3) If the meter itself is not defective and normal readings are not obtained on the d-c voltage measurements circuit (1,000 ohms per volt), make the resistance tests given in paragraph 60*c*. See figure 15.

(4) If the meter itself is not defective and normal readings are not obtained on the a-c voltage measurements circuit, make resistance tests given in paragraph 60*d*. See figure 17.

(5) If the operation of the VTVM d-c voltage measurements ranges are not normal, make the voltage and resistance tests given in paragraphs 59 and 61. See figure 18.

(6) If the operation of the resistance measurements circuit is not normal, see figure 19 for the simplified schematic diagram. Check the battery voltage, resistance network, and the switch contacts used in this circuit. Make complete voltage and resistance measurements in the circuit. When making resistance measurements, disconnect the battery.

c. Other Data. Paragraph 56 gives pertinent data which will assist the repairman in trouble shooting. Read this paragraph thoroughly before trouble shooting is started on the equipment.

56. General Trouble-shooting Data

a. Power Supply. When trouble arises in the VTVM circuits, measure the resistance between the No. 8 pin of Tube JAN-6X5 and the chassis before applying power. The normal value is approximately 20,000 ohms. If this measurement is low, capacitor C3 is either leaky or shorted or some other defect is present. If this measurement is normal, power may be applied providing Tube JAN-6C5GT/G is not defective and the resistance tests given in paragraph 59 are normal.

b. Tubes. Check the tubes before making extensive measurements. A tube tester may be used but the best test for a defective tube is the replacement method, that is, substituting a known good tube for each tube to be checked. After testing, return each good tube to its original socket.

c. Precision Resistors. Most of the resistors in the equipment are precision resistances. The accuracy of the equipment may be affected if a defective resistor is replaced with another which does not have the same resistance value.

d. Calibration Controls. The position of the movable arm of the calibration controls (R28, R30, R33, and R43) must never be moved unless a calibration adjustment is being performed. See section XIII before attempting to calibrate the instrument.

57. Meter Testing

To test the meter movement, take the following steps:

a. Remove the instrument from the cabinet.

b. Inspect the leads to the meter for breaks and loose or corroded connections. If they appear normal, disconnect them from the meter terminals.

c. Check the resistance between the two leads which were removed from the meter. If a short circuit is indicated, test the leads and the selector switches. If the leads and switches are normal, check the meter movement as explained below.

d. Connect a 5,000-ohm resistor, a 1.5-volt battery, and the meter *in series,* observing proper polarity. See figure 25. All other meter leads must be disconnected. The meter should show approximately a three-fourth scale deflection. If it does not, the meter is defective and must be replaced.

Caution: NEVER USE A HIGHER VOLTAGE OR LOWER RESISTANCE THAN SPECIFIED OR THE METER WILL BE DAMAGED.

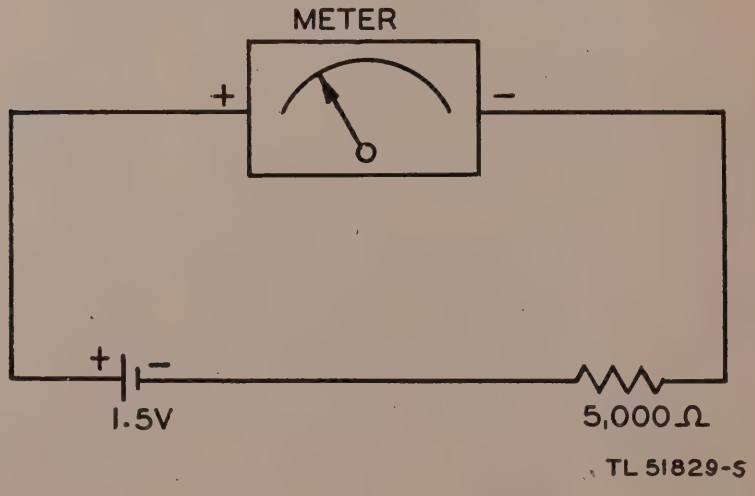


Figure 25. Meter testing circuit.

58. Starting Procedure Analysis

The following chart is based on the starting procedure given in paragraph 9.

a. STEPS 1, 2, 3, 4, 5, and 6. The first six steps of the starting procedure are preparatory.

b. STEP 7. Rotate the OHMS ZERO CHECK switch to ON.

Normal indications

(1) The white pilot lamp on the panel will go on.

(2) The meter will read approximately zero on the VTVM meter scale (center zero) after the tubes have warmed up. During the first minute, the meter pointer will swing off scale to the left and then slowly advance to the center zero setting. Finally, the pointer will remain stationary near or at the zero setting.

Abnormal indications	*Probable causes of trouble*
(*a*) The pilot light does not go on and no movement of the meter pointer is perceptible as the tubes warm up.	(*a*) 1. Plug of a-c line cord not inserted into hot socket. 2. Burned-out fuse. These fuses are located in a-c line cord plug (fig. 6). 3. Defective a-c line cord. 4. Tube JAN-OD3/VR-150 not inserted in its socket. 5. Defective Tube JAN-OD3/VR-150 tube or socket. 6. Defective switch S3 contacts. 7. Defective transformer T1. 8. Broken connection in circuit of transformer T1.
(*b*) The meter pointer does not return to approximately center-scale zero.	(*b*) See step 8*c*, below.
(*c*) The meter pointer stays off scale.	(*c*) See paragraph 56 for general trouble-shooting data. Make resistance and voltage measurements given in paragraphs 59 and 61.
(*d*) The meter pointer swings normally but the pilot lamp does not light.	(*d*) 1. Burned-out pilot lamp bulb. 2. Defective pilot lamp socket. 3. Broken connection in pilot lamp circuit.

Abnormal indications	*Probable causes of trouble*
(*e*) After the tubes have warmed up, the pointer on the meter does not remain stationary.	(*e*) 1. Poor tube. 2. Loose, dirty, or corroded connection in circuit (fig. 18). 3. Loose, dirty, or corroded switch contacts (S1 or S2). 4. Defective or open resistor in grid circuit. 5. Defective potentiometers R36, R33, or R43. Do not disturb potentiometers R33 or R43 until all other tests have been made. (See sec. XIII). 6. Make voltage and resistance tests given in paragraphs 59, 60*e*, and 61.

c. STEP 8. Rotate the V.T.V.M. ZERO ADJUST control, if necessary, to bring the meter pointer to center scale.

Normal indications

(1) Clockwise rotation of control causes the pointer to swing to the right (R).

(2) Counterclockwise rotation of control causes pointer to swing to the left (L).

(3) The pointer will rest at approximately center-scale zero when the control points at the R arrowhead.

Abnormal indications	*Probable causes of trouble*
(*a*) The rotation of control does not cause any movement of pointer.	(*a*) See probable causes of trouble under *b* (2) (*e*) above.
(*b*) Any possible adjustment of control fails to bring meter pointer to center-scale zero.	(*b*) 1. Poor tube. 2. Defective part or connection. 3. See probable causes of trouble under *b* (2) (*e*) above.

d. STEP 9. Rotate the master-range selector switch to each of the other five voltage ranges.

Normal indications

(1) Meter pointer will remain within one division of center-scale zero at any position of switch on voltage ranges.

Abnormal indications	*Probable causes of trouble*
(*a*) Meter pointer does not remain within one division of zero on one or more of the voltage ranges.	(*a*) 1. Poor tube JAN-6C5GT/G. 2. Defective resistor in circuit (fig. 18). 3. Loose, dirty, or corroded connection. 4. Loose, dirty, or corroded selector switch contacts. 5. Make resistance and voltage measurements given in paragraphs 59, 60*e*, and 61.

e. STEP 10. Rotate the master-range selector switch to the 2000 MEGS. position and then to the other resistance ranges.

Normal indications

(1) The meter pointer will swing to the right or off scale to the right on all ranges.

Abnormal indications	*Probable causes of trouble*
(*a*) Pointer does not swing normally when switch is placed in 2000 MEGS. position.	(*a*) 1. Defective switch contacts (S2). 2. Open resistor R27. Check this by rotating switch S2 to one of the other resistance ranges. If the resistor is defective and the switch contacts are not at fault, the meter pointer will swing to the right on the other ranges. 3. Broken connection between tap on potentiometer R36 and the positive terminal of dry-cell battery.
(*b*) Pointer swings normally on 2000 MEGS. range but does not swing normally on one or more of the other ranges.	(*b*) Defective resistor or switch S2 contacts for the range showing the abnormality (see fig. 19 for circuit).

f. STEP 11. Rotate the OHMS ZERO ADJUST control until the meter pointer rests at the infinity mark (∞) on the OHMS scale.

Normal indications

(1) The meter pointer will rest on the infinity mark at one setting of the control.

Abnormal indications	*Probable causes of trouble*
(*a*) Any setting of control fails to bring pointer to the infinity mark.	(*a*) 1. Abnormal output voltage from regulated rectifier. Check voltage between pin 5 of Tube JAN-OD3/VR-150 and the chassis. It should be 150 volts. If not, check the tubes and the power rectifier. Make voltage and resistance measurements given in paragraphs 59 and 61.
	2. Poor Tube JAN-6C5GT/G.
	3. Defective fixed resistor in bridge or meter circuit of figure 19.
	4. Shorted or leaky capacitor C4.
	5. Defective meter.
	6. Loose, dirty, or corroded switch contacts (S2 or S1).
	7. Poor connection (fig. 19).
	8. Defective potentiometers R36 or R39.
	9. Defective calibration control (potentiometers R33 or R43). Do not disturb these controls unless all other tests indicate that one of the controls is out of adjustment or defective.
	10. See section XIII.
	11. Make voltage and resistance tests given in paragraphs 59 and 61.

g. STEP 12. Rotate the OHMS ZERO CHECK switch to the OHMS CHECK position and the V.T.V.M. ZERO ADJUST control until the meter pointer rests at zero on the OHMS scale. Then release the OHMS ZERO CHECK switch.

Normal indications

(1) The pointer can be adjusted to zero on the OHMS scale by rotation of the V.T.V.M. ZERO ADJUST control when the OHMS ZERO CHECK switch is held in the OHMS CHECK position.

Abnormal indications	*Probable causes of trouble*
(*a*) Any adjustment of control fails to bring pointer of meter to the zero mark.	(*a*) 1. Poor batteries. Total battery voltage should be 6 volts (1.5 volts per cell). 2. Defective contacts on switch S3. 3. Broken connection. 4. Defective potentiometer R39. 5. Defective contacts on switch S2. 6. Poor connection in circuit (fig. 19).

h. STEP 13. Repeat steps 11 and 12 until the meter pointer rests at the infinity mark on the OHMS scale when the OHMS ZERO CHECK switch is released, and at the zero mark on the OHMS scale when the switch is held in the OHMS CHECK position.

Normal indications

(1) Explained under action for step 13 above.

Abnormal indications	*Probable causes of trouble*
(*a*) Any settings of controls fail to bring meter pointer to proper settings.	(*a*) See probable causes of trouble under steps 11 and 12 above.

i. STEP 14. Rotate the CIRCUIT SELECTOR switch to the AC. V. DB. position. The meter pointer will return to the zero mark on the A.C. or D.C. scale. If not, see step 4 of the starting procedure.

Section XI. TEST AND ANALYSIS DATA

59. Resistance Measurements from Tube Pins to Chassis

In the chart below all values given are in ohms; values are approximate. Measurements have been made with master-range selector switch in the 600V. position and with the CIRCUIT SELECTOR switch in the

V.T.V.M. OHMS position. In addition, the tubes were in their sockets and the battery voltage source was removed. The plug of the a-c line cord was removed from the a-c power source.

Pin No.	Tube		
	JAN-6C5GT/G	JAN-6X5	JAN-OD3/VR-150
1	0	NC	∞
2	0	20,000	0
3	14,000	260	∞
4	*NC	NC	NC
5	560,000	260	15,000
6	*NC	NC	∞
7	0.2	20,000	NC
8	4,000	20,000	∞

∞ = infinity.

*NC means no connection

60. Other Resistance Measurements

The following subparagraphs show various resistance measurements which are of value during trouble shooting.

a. Transformer Resistance Measurements. All values given below are approximate. The plug on the a-c line cord was removed from the a-c power source. Measurements were made with tubes in their sockets.

Primary winding (measured between transformer terminals No. 7 and 9) ..... 10.5 ohms

High-voltage secondary winding (measured between transformer terminals No. 1 and 5) ..... 520 ohms

Rectifier filament winding (measured between transformer terminals No. 8 and 10) ..... 0.2 ohms

Filament winding for 6C5GT/G tube (measured between transformer terminals No. 2 and 4) ..... 0.2 ohms

b. Resistance Measurements in Current Measurements Circuit. It is not necessary to remove the chassis from the cabinet for these tests. The plug on the a-c line cord was removed from the a-c power source for these measurements. All values are approximate.

Caution: Make these tests with the CIRCUIT SELECTOR switch in the V.T.V.M. OHMS position.

Between pin jacks marked 12 AMPS..... 0.04 ohms

Between pin jacks marked EXTERNAL TESTS for the following settings of the master-range selector switch:

1200MA.	0.5 ohms
300MA.	1.65 ohms
60MA.	7.6 ohms
12MA.	38.0 ohms
3MA.	160.0 ohms
.6MA.	800.0 ohms

c. Resistance Measurements for D-c Voltage Ranges (1,000 ohms per volt). When making the following measurements it is not necessary to remove the chassis from the cabinet. All values are approximate. Measurements were made with the plug of the a-c line cord removed from the a-c power source.

Caution: Make these measurements with the CIRCUIT SELECTOR switch at the DC. V. MA. POSITION.

Between +6000V. and +1200V. pin jacks	4.8 megs
Between +1200V. and + EXTERNAL TEST pin jacks	600,000 ohms
Between the + and — EXTERNAL TESTS pin jacks for the following positions of the master-range selector switch:	
3V.	3,100 ohms
6V.	6,200 ohms
12V.	12,400 ohms
60V.	62,000 ohms
300V.	310,000 ohms
600V.	620,000 ohms

d. Resistance Measurements for A-c Voltage Ranges. When making the following measurements it is not necessary to remove the chassis from the cabinet. All values are approximate. Measurements were made with the plug of the a-c line cord removed from the a-c power source.

Caution: When making measurements, use only the higher ranges of the test ohmmeter. Otherwise, the meter on the multi-range tester will go off scale and possibly damage the meter movement.

Between +6000V. and +1200V. pin jacks	4.8 megs
Between +1200V. and + EXTERNAL TESTS pin jacks	600,000 ohms
Between the + and — EXTERNAL TESTS pin jacks for the following settings of the master-range selector switch:	
3V.	3,300 ohms
6V.	6,600 ohms
12V.	13,200 ohms
60V.	66,000 ohms
300V.	330,000 ohms
600V.	660,000 ohms

e. Resistance Measurements for D-c Voltage for Ranges (VTVM). The following measurements are made from the front panel. All values are approximate. Measurements were made with plug of the a-c line cord removed from the a-c power source.

Caution: Do not attempt to measure the resistance between the MEGOHMMETER terminals marked HIGH and SHIELD unless the batteries are disconnected.

Between the 6000V. and 1200V. pin jacks	106.66 megs
Between the 1200V. and ±V.T.V.M. TESTS pin jacks	13.33 megs
Between the No. 1 contact of the plug on the circuit isolating test leads cable and the prod on the same cable	1.33 mgs
Between the ± and GND. V.T.V.M. TESTS pin jacks	13.33 megs
Between the MEGOHMMETER pin jack marked HIGH and the V.T.V.M. TESTS pin jack marked GND. for the following settings of the master-range selector switch:	
3V.	12 megs
6V.	6 megs
12V.	3 megs
60V.	600,000 ohms
300V.	120,000 ohms
600V.	60,000 ohms

61. Voltage Measurements from Tube Pins to Chassis

In the following chart all voltages are direct current unless otherwise noted. All values are approximate. Measurements were taken with tubes in sockets with the master-range selector switch at the 600V. position and the CIRCUIT SELECTOR switch at the V.T.V.M. OHMS position. Measurements were made with a 1,000-ohms per volt meter.

Pin No.	Tube		
	JAN-6C5GT/G	JAN-6X5	JAN-OD3/VR-150
1	0	0	0
2	0	330 v	0
3	135 v	270 v ac	ac
4	0	0	0
5	0	270 v ac	150 v
6	0	0	0
7	6 v ac	330 v	ac
8	5.5 v	330 v	0

Section XII. REPAIRS

62. Servicing

Be careful in maintaining and servicing this equipment. Servicing and repair other than the replacement of tubes should be performed only by competent personnel supplied with adequate tools and instruments. An inexperienced operator attempting to locate and repair troubles may damage the equipment to such an extent that shipment to a higher repair echelon will be necessary. This is particularly true of indiscriminate adjustment of the calibrating potentiometers.

a. Connections. Before a part is unsoldered, note the position of the leads. If the part has a number of connections, tag each of the leads.

b. Damage to Leads. Be careful not to damage other leads by pulling or pushing them out of the way.

c. Solder Drops. Do not allow drops of solder to fall into the set. They may cause short circuits.

d. Proper Soldering. A carelessly soldered connection may create a new fault which is one of the most difficult faults to find. Do not use acid core solder in making repairs.

e. General. The failure of one part may be due to a defect in some other part of the circuit. Do not replace a defective part if the cause of its failure is not also corrected.

63. Operation Check

After the instrument has been repaired, the following tests may be used to determine if its operation will be satisfactory:

a. Make voltage measurements by connecting the repaired instrument and a good instrument to the same voltage source. Connect both instruments to the source at the same time to eliminate the effect of possible difference in loading. Make measurements on both D.C. and A.C. ranges using several different values of voltage. Both instruments should read approximately the same for each test.

b. Take voltage readings from the same source but using different voltage ranges. For example, 2 volts will give a satisfactory deflection on both the 3-volt and 6-volt ranges. Other values will give satisfactory deflections on other ranges. Readings obtained from the same source on successive ranges should not vary more than 5 percent.

c. Make resistance measurements on assorted resistors. However, do not connect two meters across the same resistor. These measurements should be made individually.

d. If the second instrument will measure current, the two may be connected in series with a source of voltage and a variable resistor (fig. 26). Both instruments should indicate approximately the same current on all ranges. Start the test with the variable resistor adjusted for maximum resistance.

e. If the second instrument does not have provisions for measuring current, the following test may be used:

(1) Connect a battery and resistor in series and measure the current flow.

(2) Measure the battery voltage with the resistor connected.

(3) Measure the resistor with the battery disconnected.

(4) Substitute the voltage and resistance values in the formula $I = \frac{E}{R}$ and solve for the current flow. The calculated value and the measured value should be approximately equal. An error in any of the readings will, of course, make exact results impossible, but the test will give a fair approximation.

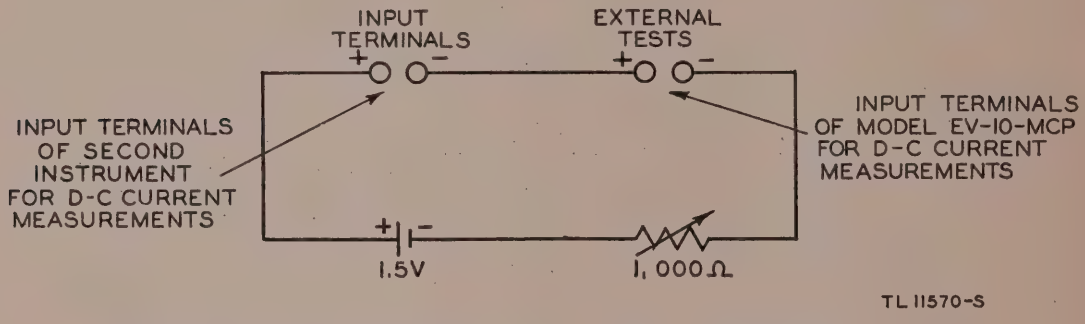


Figure 26. Method of testing the d-c current measurements circuit.

64. Rustproofing and Repainting

If the finish on the cabinet has been badly scarred or damaged, prevent rust and corrosion by touching up the bared surface as follows:

a. Clean the scarred surface down to the bare metal. Use #00 or #000 sandpaper to obtain a bright, smooth finish.

Caution: THE USE OF STEEL WOOL INSTEAD OF SANDPAPER IS NOT RECOMMENDED. MINUTE PARTICLES OF THE METAL FREQUENTLY ENTER THE CABINET AND CAUSE HARMFUL INTERNAL ELECTRICAL SHORTING OR GROUNDING OF CIRCUITS.

b. When a touch-up job is necessary, apply paint with a small brush. When numerous scars and scratches warrant a complete repainting job, remove the chassis and spray paint over the entire cabinet. Remove rust from the case by cleaning corroded metal with dry-cleaning solvent (SD). In severe cases it may be necessary to use dry-cleaning solvent (SD) to soften the rust and sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section XIII. CALIBRATION

65. General

Calibration of the equipment is initially performed by the manufacturer. After this calibration, potentiometers R28, R30, R33, and R43 are sealed. Recalibration is rarely necessary and should not be performed unless it is definitely known that adjustments must be made. When performing trouble shooting, make all other possible tests before attempting recalibration. Recalibration in the field is reduced to emergency adjustments since it is not usually possible to reach the degree of accuracy which can be accomplished at a depot shop.

66. Replacement of a Calibration Control

The likelihood of a defective calibration potentiometer is remote because in the event of a short-circuited condition, one of the other parts in the circuit will usually fail first. If, however, one of these controls do require replacement, use the following procedure:

a. Unsolder the connections to the control.

b. Remove the control from the terminal board.

Note. Do not disturb the position of the movable arm on the control when performing the above steps.

c. Note the position of the movable arm on the control. Then adjust the movable arm on the new control to approximately the same physical position.

d. Mount the new control on the terminal board.

e. Solder the connections in place.

f. Place the equipment in operation and check the accuracy of meter readings by measuring voltage or resistance of *known* value.

g. If the readings are normal, no further work is necessary. If, however, the readings are abnormal, recalibration is necessary; use the procedure given in paragraphs 67 or 68.

67. Emergency Calibration of A-c Voltage Measuring Circuit

Potentiometers R28 and R30 (figs. 9 and 23) are used for this operation. Use the following procedure:

a. Remove the seals from the shafts of the two controls.

b. Measure the resistance of resistor R1. It should be approximately 3,000 ohms. Note on a piece of paper the exact resistance value.

c. Set the CIRCUIT SELECTOR switch at the A.C.V. DB. position.

d. Set the master-range selector switch at the 3V. position.

e. Measure the resistance between the EXTERNAL TESTS terminals. The resistance should have the same value as that noted on the piece of paper. If it does not, adjust potentiometer R28 until the two values are equal.

f. Apply an a-c voltage of *known* value (3 volts or less) to the EXTERNAL TESTS terminals and note the meter reading. The pointer should indicate the value of the applied voltage. If it does, the calibration is complete. If it does not, adjust potentiometer R30 until the meter reading shows the value of the applied voltage.

g. Repeat the instructions given in *e* and *f* above several times if necessary, until the measured resistance between the EXTERNAL TESTS terminals has the same value as that noted for resistor R1, and until the meter registers accurately the value of an applied voltage.

h. If the value of resistor R1 is normal, this calibration will serve for all a-c voltage ranges.

Note. The resistance of R1, if normal, will be one-half the resistance of R2, one-sixteenth the resistance of R3, one-eightieth the resistance of R4, etc.

68. Emergency Calibration of VTVM Circuit

Potentiometers R33 and R43 (figs. 11 and 23) are the calibration controls used in this operation. Use the following procedure:

a. Perform steps 1, 2, 3, 4, 5, and 6 of the starting procedure given in paragraph 9. *Do not* perform steps 7 through 14.

b. Rotate the OHMS ZERO CHECK switch to ON position and allow the instrument to warm up for approximately 15 minutes.

c. Leave the V.T.V.M. ZERO ADJUST control with its pointer at the R arrowhead throughout the adjustments given in this paragraph.

d. Rotate potentiometer R43 to its maximum clockwise position.

Note. Clockwise rotation of either R33 or R43 is determined when viewing control from the rear of the chassis or when facing the screw-driver slot on the shaft of the control. It will be necessary to break the seals of these controls before adjustments can be made.

e. Rotate potentiometer R33 until the pointer of the meter rests at center-scale zero.

f. Connect a source of d-c voltage of *known* value (3 volts or less) to the V.T.V.M. TESTS terminals and note the meter reading on a piece of paper. Then reverse the polarity of the input voltage and again note the meter reading on the piece of paper opposite the first reading. These readings will probably be the same, except for polarity.

g. Disconnect the d-c voltage source. Rotate R43 approximately one-

eighth turn counterclockwise and then adjust R33 until a center-scale zero reading is again obtained.

h. Repeat the instructions given in *f* above and note the new readings on the piece of paper.

i. Repeat the instructions of subparagraph g and then the instructions of subparagraph f above until R43 has been rotated to its maximum counter-clockwise position. Note each time on the piece of paper the readings obtained when the d-c voltage source is connected.

j. Observe from the record kept, the position of R43 where the correct d-c voltage reading was obtained. Return R43 to approximately this position and reset R33 for a center-scale zero reading.

k. Finally, measure the known d-c voltage again. The reading should indicate the correct value. If it does not, make slight readjustments of the controls. When making these adjustments, use the same general procedure given in subparagraphs f and g above but move R43 in steps of less than one-eighth revolution.

69. Checking Resistance Ranges after Calibration

After the calibration given in paragraph 68 above has been made, the resistance ranges should also be properly calibrated. Check this by using the following procedure:

a. Perform the first 13 steps of the starting procedure given in paragraph 9.

b. Measure *known* values of resistance at different settings of the master-range selector switch and check the accuracy of readings.

c. When the instrument is properly calibrated, the pointers of the V.T.V.M. ZERO ADJUST and the OHMS ZERO ADJUST controls will be approximately upright after step 13 of the starting procedure is performed. In addition correct resistance measurements will be obtained.

70. Unsatisfactory Equipment Report

a. When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report (WD AGO Form 468) should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form 54 should be filled out and forwarded through channels.

c. If either form is not available, prepare the data according to the sample form reproduced in figure 27.

WAR DEPARTMENT

UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: Signal Corps MATÉRIEL		DATE: 1 Feb 45
FROM	ORGANIZATION: 175 Signal Repair Co.		STATION: APO 102
TO	NEXT SUPERIOR HEADQUARTERS: Supply Sec. Hq Fourth Army Sig Sv.	STATION: APO 110	TECHNICAL SERVICE: Signal Corps

COMPLETE MAJOR ITEM

NOMENCLATURE	TYPE	MODEL	
Radio Transmitter BC-123-A	Ground, vehicular	A	
MANUFACTURER	**U. S. A. REG. No. / Order No.**	**SERIAL No.**	**DATE RECEIVED**
American Radio Corp	1234-Phila-45	12345	5 Jan 45

EQUIPMENT WITH WHICH USED (*If applicable*): Radio Set SCR-456-A — Tank, Medium, M4

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART No.	TYPE	MANUFACTURER	DATE INSTALLED
Sig C Stk. No. 3E47-2	Capacitor C20: fixed; 1-mf; 500 vdcw	American Radio Corp	when manufactured

DESCRIPTION OF FAILURE AND PROBABLE CAUSE (*If additional space is required, use back of form*)

Capacitor C20 shorts out due to humid operating conditions

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
15 Jan 45	-	-	-	0	0	5		-	-

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN

Operation in tropics; heavy rainfall. Was replaced and set given moistureproofing and fungiproofing treatment, 20 Jan 45.

TRAINING OR SKILL OF USING PERSONNEL			RECOMMENDATIONS (*If additional space is required, use back of form*)
POOR	FAIR	GOOD	
		X	Substitute capacitor designed for tropical operation

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION	SIGNATURE
E. A. WILSON, 1st Lt., Sig C 175 Sig Repair Co.	E. A. Wilson

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in matériel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of matériel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (change No. 3).
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels.
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

TL19589

U. S. GOVERNMENT PRINTING OFFICE 16—41540-1

Figure 27. Sample of WD AGO Form 468 (Unsatisfactory Equipment Report).

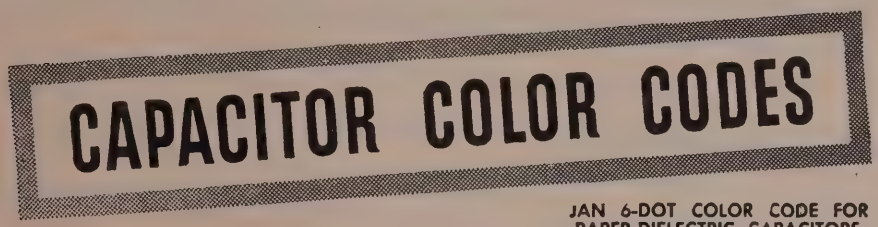
Section XIV. DIAGRAMS

71. Complete Schematic Diagram (See fig. 30.)

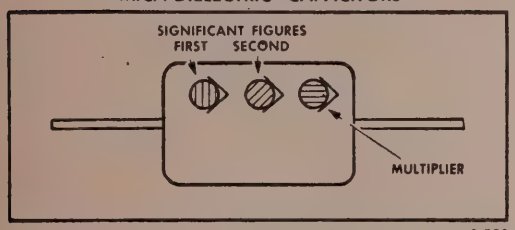
APPENDIX I

REFERENCES

1. Color Codes (See figs. 28 and 29.)

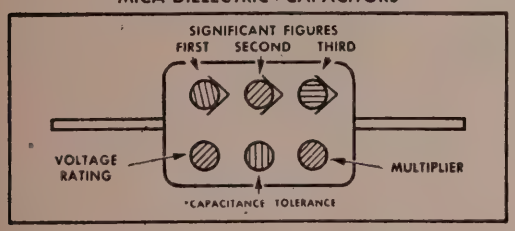


RMA 3-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS

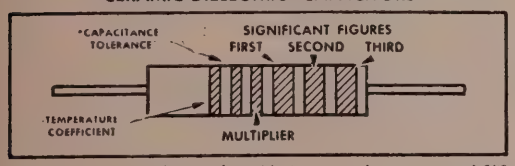


Capacitors marked with this code have a voltage rating of 500 volts

RMA 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



RMA COLOR CODE FOR TUBULAR CERAMIC-DIELECTRIC CAPACITORS



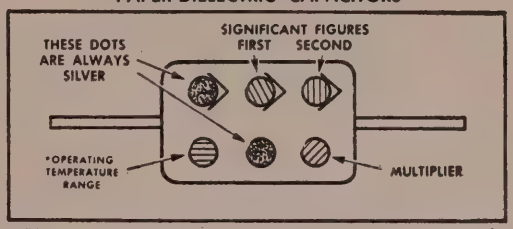
Capacitors marked with this code have a voltage rating of 500 volts

RMA Radio Manufacturers Association JAN Joint Army Navy

Note: These color codes give all capacitances in micromicrofarads

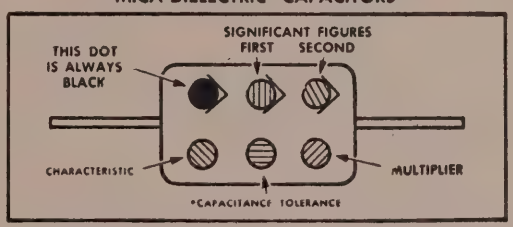
Items marked with an asterisk are of interest primarily to depot and higher echelon repair personnel

JAN 6-DOT COLOR CODE FOR PAPER-DIELECTRIC CAPACITORS



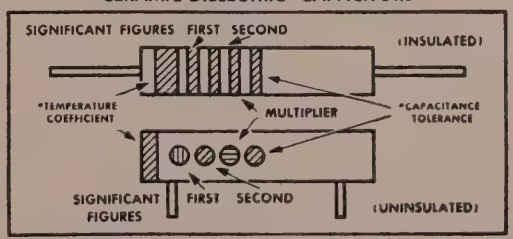
The silver dots serve to identify this marking For working voltages see JAN type designation code

JAN 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



The black dot serves to identify this code For working voltages see JAN type designation code

JAN COLOR CODE FOR FIXED CERAMIC-DIELECTRIC CAPACITORS



Capacitors marked with this code have a voltage rating of 500 volts. Either the band or dot code may be used.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER			RMA VOLTAGE RATING
		RMA MICA-AND CERAMIC-DIELECTRIC	JAN MICA-AND PAPER-DIELECTRIC	JAN CERAMIC-DIELECTRIC	
BLACK	0	1	1	1	
BROWN	1	10	10	10	100
RED	2	100	100	100	200
ORANGE	3	1,000	1,000	1,000	300
YELLOW	4	10,000			400
GREEN	5	100,000			500
BLUE	6	1,000,000			600
VIOLET	7	10,000,000			700
GRAY	8	100,000,000		0.01	800
WHITE	9	1,000,000,000		0.1	900
GOLD		0.1	0.1		1,000
SILVER		0.01	0.01		2,000
NO COLOR					500

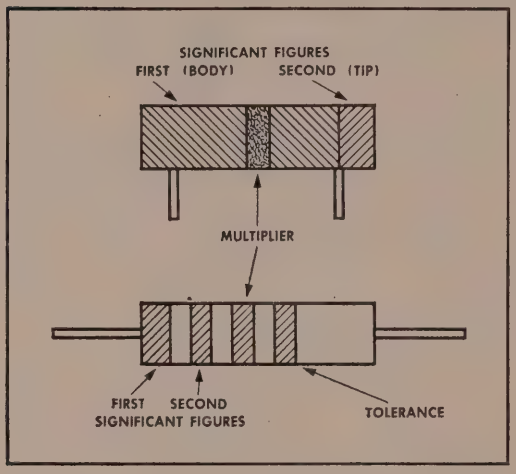
TL13417A

858-Ft Mon.-6-6-45-500

Figure 28. Capacitor color codes.

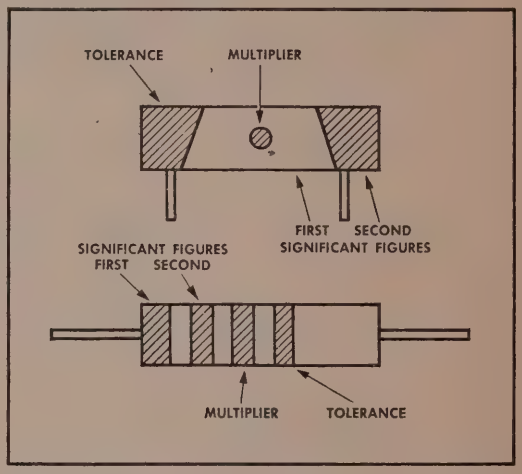
RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS



Insulated fixed composition resistors with axial leads are designated by a natural tan background color. Non-insulated fixed composition resistors with axial leads are designated by a black background color

JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS



Resistors with axial leads are insulated. Resistors with radial leads are uninsulated.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	
RED	2	100	
ORANGE	3	1,000	
YELLOW	4	10,000	
GREEN	5	100,000	
BLUE	6	1,000 000	
VIOLET	7	10,000,000*	
GRAY	8	100,000,000*	
WHITE	9	1,000,000,000*	
GOLD		0 1*	5
SILVER		0.01*	10
NO COLOR			20

*JAN ONLY

Example: A 50,000-ohm resistor with a standard tolerance of 20 percent (no color) would be indicated by a green ring (5) a black ring (0), and an orange ring (000)

RMA Radio Manufacturers Association
JAN Joint Army-Navy

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Figure 29. Resistor color codes.

2. Army Regulations

AR 380-5, Safeguarding Military Information.

3. Supply Publications

SIG 1, Introduction to ASF Signal Supply Catalog.

SIG 2, Complete Index to ASF Signal Supply Catalog.

SIG 3, List of Items for Troop Issue.

SIG 4-1, Allowances of Expendable Supplies.

SIG 4-2, Allowances of Expendable Supplies for Schools, Training Centers, and Boards.

SIG 5, Stock List of All Items.

SIG 10, Fixed Plant Maintenance Lists.

SB 11-6, Dry Battery Supply Data.

SB 11-10, Signal Corps Kit and Materials for Moisture and Fungi-Resistant Treatment.

SB 11-17, Electron Tube Supply Data.

4. Technical Manuals on Test Equipment

TM 11-303, Test Sets I-56-C, I-56-D, I-56-H, and I-56-J.

TM 11-321, Test Set I-56-E.

TM 11-472, Repair and Calibration of Electrical Measuring Instruments.

TM 11-1204, Test Set I-167.

TM 11-2532, Test Set I-153-A.

TM 11-2613, Voltohmmeter I-166.

TM 11-2626, Test Unit I-176.

TM 11-2627, Tube Tester I-177.

5. Shipping Instructions

U. S. Army Spec. No. 100-14A, Army-Navy General Specification for Packaging and Packing for Overseas Shipment.

6. Decontamination

TM 3-220, Decontamination.

7. Demolition

FM 5-25, Explosives and Demolition.

8. Other Technical Publications

FM 21-6, List and Index of War Department Publications.

FM 21-7, List of Training Films, Film Strips, and Film Bulletins.

TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment.

TB SIG 66, Winter Maintenance of Ground Signal Equipment.

TB SIG 72, Tropical Maintenance of Ground Signal Equipment.

TB SIG 75, Desert Maintenance of Ground Signal Equipment.

TM 1-455, Electrical Fundamentals.

TM 11-453, Shop Work.

TM 11-455, Radio Fundamentals.

TM 11-462, Reference Data.

TM 37-250, Basic Maintenance Manual.

9. Forms

WD AGO Form 468.

Army Air Forces Form 54.

10. Abbreviations

The following abbreviations are used in this manual:

a-c	alternating-current	ma	milliampere
amp	ampere	meg	megohm
d-c	direct-current	mf	microfarad
db	decibel	mw	milliwatt
∞	infinity	rf	radio frequency
i-f	intermediate-frequency	r-m-s	root-mean-square
JAN—	Prefix designation for radio electron tubes procured under joint Army-Navy Specification JAN-1A	v	volt
		VTVM	vacuum-tube voltmeter
		W-W	wire-wound
		W.V.	working voltage
M	1,000 ohms	Ω	ohms

APPENDIX II

MAINTENANCE PARTS

The following information was compiled on 29 March 1945. The appropriate section of the ASF Signal Supply Catalog for Vacuum Tube Voltmeter, (Precision Model EV-10-MCP) is:

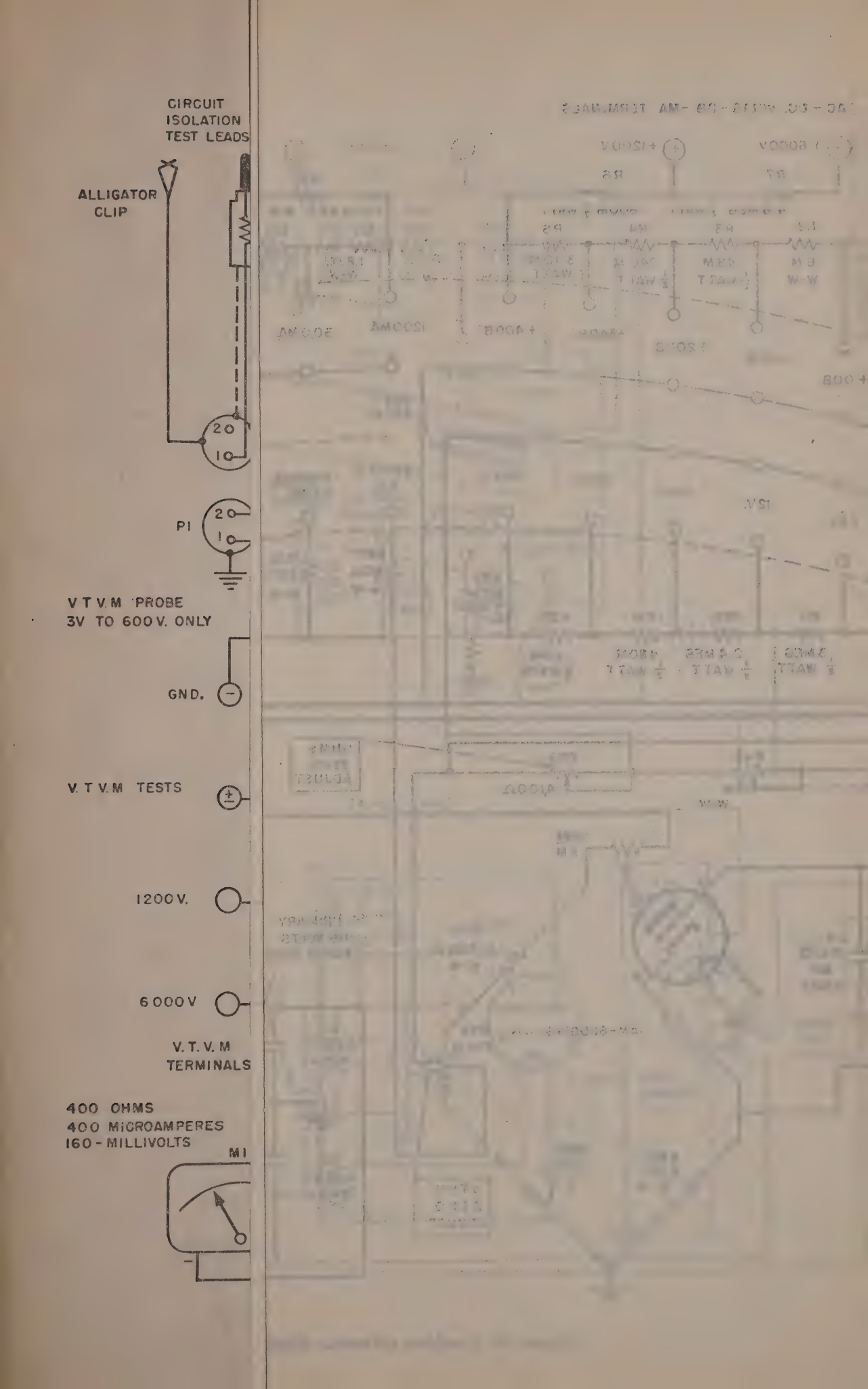
Fixed Plant Maintenance List:

SIG 10-422.2

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

Note. The following table lists maintenance parts in station stock.

Ref.	Sig. C Stock No.	Description
Figure 30	2Z5877-5	LAMP, pilot
JAN-6C5GT/G	2J6C5GT	TUBE
JAN-6X5	2J6X5	TUBE
JAN-OD3/VR-150	2JVR-150-30	TUBE


CIRCUIT
ISOLATION
TEST LEADS
ALLIGATOR
CLIP
20
10
P1
2
1
V T V.M PROBE
3V TO 600V. ONLY
GND.
V. T V.M TESTS
1200V.
6000V
V. T. V. M
TERMINALS
400 OHMS
400 MICROAMPERES
160 - MILLIVOLTS
M1

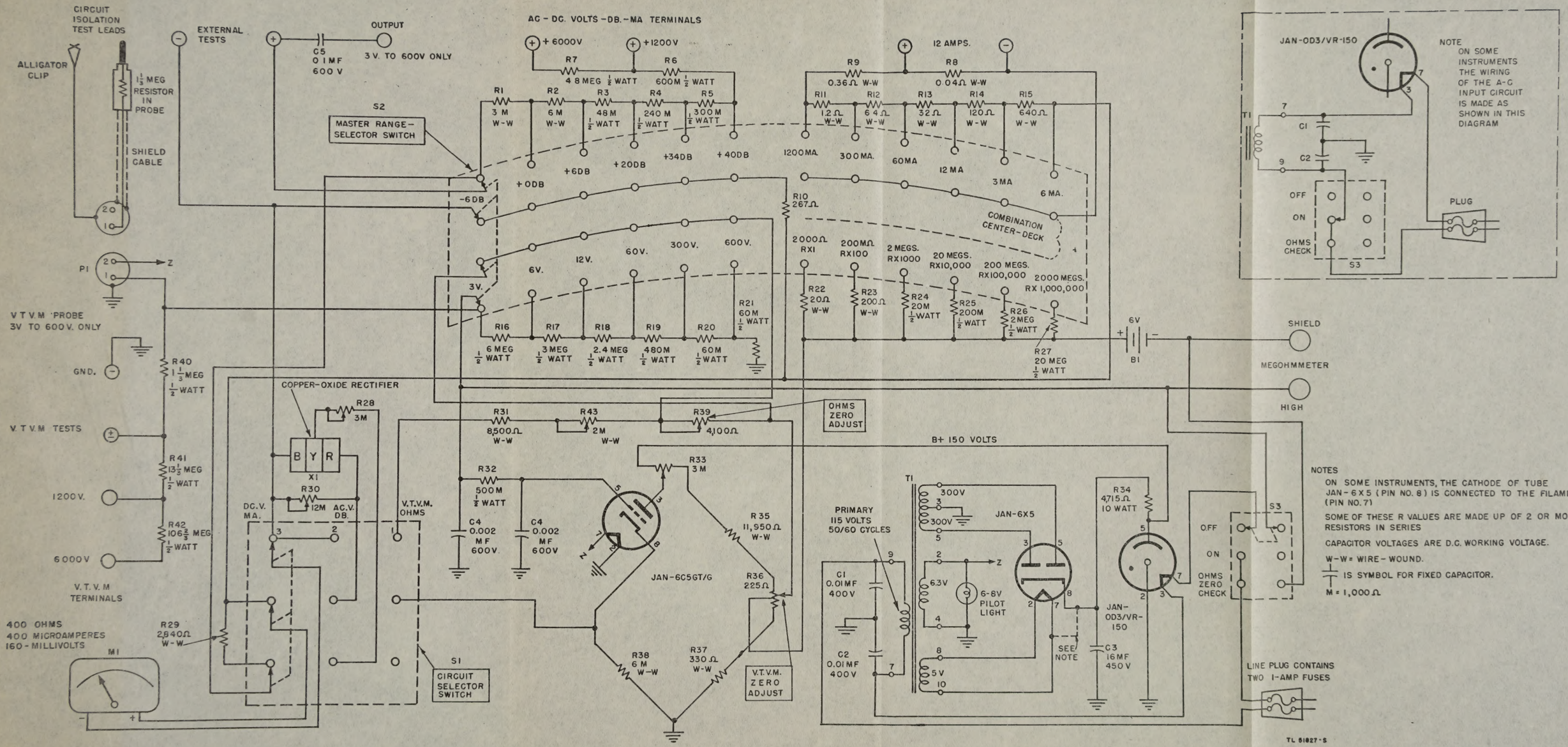
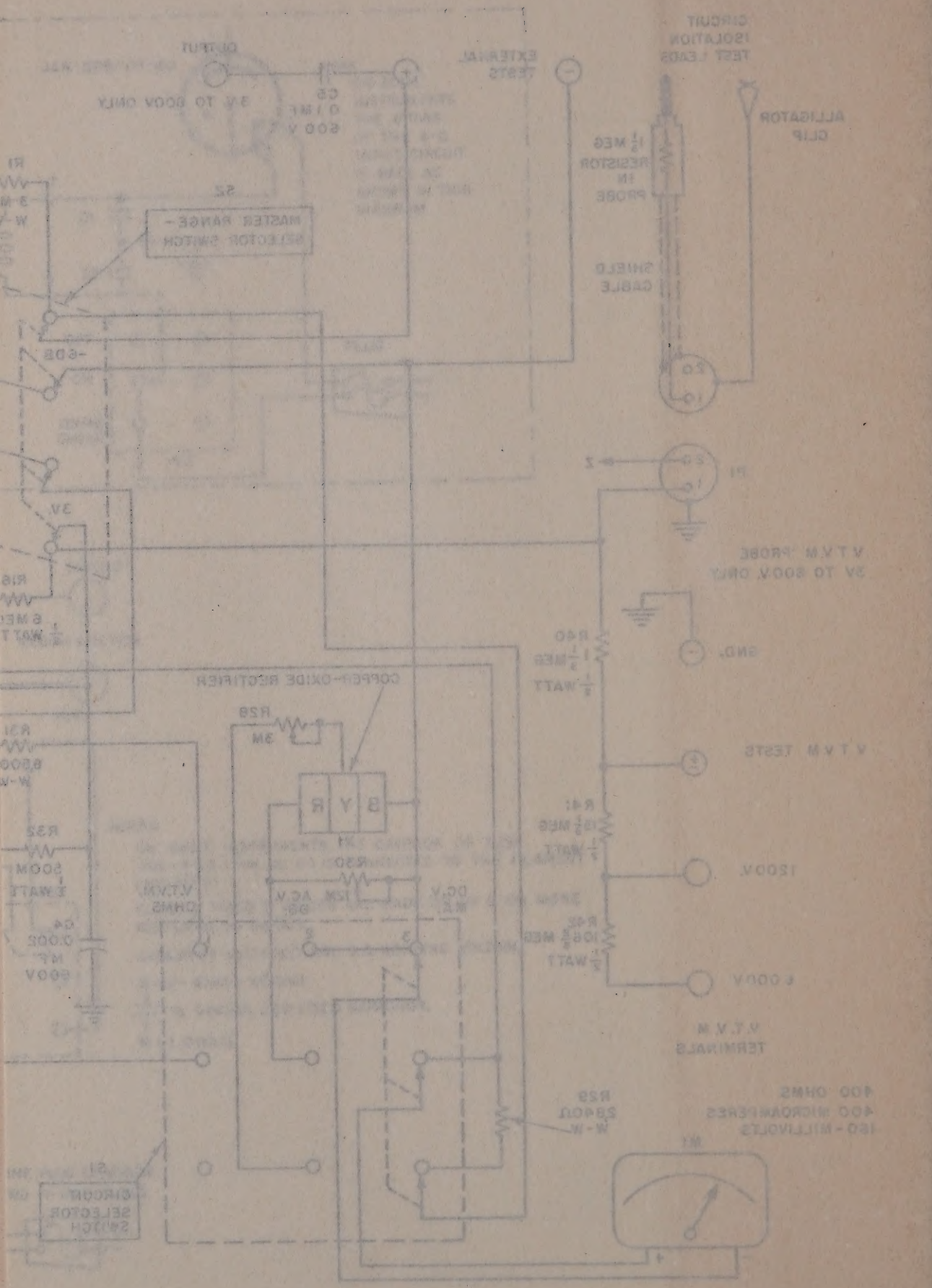


Figure 30. Complete schematic diagram.


OUTPUT
3V TO 600V ONLY
EXTERNAL TESTS
CIRCUIT ISOLATION TEST LEADS
ALLIGATOR CLIP
1½ MEG RESISTOR IN PROBE
SHIELD CABLE
MASTER RANGE-SELECTOR SWITCH
-6DB
3V
COPPER-OXIDE RECTIFIER
R29 3M
B Y R
R30 12K
R40 1½ MEG ½ WATT
R41 10½ MEG ½ WATT
R42 10½ MEG ½ WATT
R32 500M ½ WATT
C4 0.002 MF 600V
SIGNAL SELECTOR SWITCH
R29 2940Ω W-W
400 OHMS
400 MICROAMPERES
150-MILLIVOLTS
V.T.V.M TERMINALS
V.T.V.M PROBE
3V TO 600V ONLY
V.T.V.M TESTS
SIG.
120V.
600V.